LAWRENCE LIVERMORE NATL LAB (SITE 300) (USDOE)

Site Information:

Site Name: LAWRENCE LIVERMORE NATL LAB (SITE 300) (USDOE)
Address: LIVERMORE, CA

EPA ID: CA2890090002
EPA Region: 09

Record of Decision (ROD):

ROD Date: 09/26/1995
Operable Unit: 02
ROD ID: EPA/ROD/R09-95/141

Media: soil, groundwater

Contaminant: VOCs, LNAPLs, diesel fuel, T-BOS, TCE, PCE, cis-1,2-DCE, 1,1,1-TCA, benzene, chloroform, 1,1-DCE, ethylbenzene, freon, methylene chloride, toluene,

Abstract: Please note that the text in this document summarizes the Record of Decision for the purposes of facilitating searching and retrieving key text on the ROD. It is not the officially approved abstract drafted by the EPA Regional offices. Once EPA Headquarters receives the official abstract, this text will be replaced.

Lawrence Livermore National Laboratory (LLNL), Site 300, is a Department of Energy (DOE)-owned experimental test facility. It is located in the southeastern Altamont Hills of the Diablo Range, about 17 miles east-southeast of Livermore and eight and a half miles southwest of Tracy, California. The site is bordered by cattle grazing land, a California Department of Fish and Game ecological preserve, an outdoor recreational facility, and a privately owned high explosives (HE) testing facility. For the purpose of this Interim Record of Decision, it is understood that Site 300 will remain under the continued control of DOE.

The Building 834 operable unit (OU) is located on a north-south trending ridge in the southeastern part of Site 300, and was established to address soil and groundwater contamination in the subsurface below the facility. However, only soil remediation is discussed in this interim ROD.

Prior to being used as a test facility, the Building 834 area was used for cattle ranching and livestock grazing. Since the 1950s, the facilities have been used to expose test specimens to thermal shock, thermal cycling, and long-term elevated or reduced temperatures.

TCE served as the primary heat transfer fluid for these operations until the entire system was dismantled between September 1993 and May 1994. The LLNL estimates that about 550 gallons of TCE, a suspected human carcinogen, leaked and spilled to the ground surface and a nearby septic system leach field, contaminating the soil and shallow groundwater in the area. Other chemical compounds commonly detected in the perched groundwater in the Building 834 area include tetrachloroethylene (PCE), 1,2-dichloroethylene (DCE), 1,1,1-trichloroethane (TCA), T-BOS, and diesel fuel.

Since the discovery of contamination at Building 834, some of the VOCs in the subsurface have been remediated by soil excavation, soil venting, and groundwater extraction and treatment. In addition, this facility has already been used as a test bed for several innovative technology treatability projects, including an EPA Superfund Innovative Technology Evaluation (SITE) test of a pulsed ultraviolet soil vapor treatment system, an electrical soil heating pilot test, and a demonstration of an electron accelerator to treat soil vapor.

Remedy: The major components of the selected remedy include: installation of additional dedicated soil vapor monitoring points to monitor the progress of remediation; sealing and abandonment of several existing groundwater monitoring wells; modification of ventilation systems in selected buildings to increase air circulation and reduce any potential inhalation risk from TCE vapors that may be migrating into buildings from subsurface soil; institutional exposure controls such as fences, warning signs, and excavation and/or construction restrictions; surface water drainage controls, such as asphalt paving, to reduce recharge of precipitation to the perched water-bearing zone; light nonaqueous-phase liquid (LNAPL) extraction and treatment (T-BOS and diesel) to reduce the mass of these contaminations; extracted LNAPLs will be removed from groundwater using an oil-water separator, skimmer, or equivalent system; soil vapor extraction (SVE)and treatment - extracted soil vapor will be treated using granular activated carbon or other technology; partial dewatering of the perched water-bearing zone in the vicinity of the release areas to enhance the effectiveness of SVE by exposing a larger soil volume to vapor flow and extracted groundwater will be treated by a low-profile air stripper with granular activated carbon emissions control; and innovative technology development for enhanced

removal of undissolved TCE DNAPL in the vadose zone and in shallow perched groundwater.

Text: Full-text ROD document follows on next page.

Text:

UCRL-AR-119791

Interim Record of Decision

for the Building 834 Operable Unit

Lawrence Livermore National

Laboratory Site 300

September 1995

Environmental Protection Department
Environmental Restoration Division

Work performed under the auspices of the U S. Department of Energy by Lawrence Livermore National Laboratory
under Contract W-7405-Eng-48.

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1. Declaration

1.1. Site Name and Location

The site described in this Interim Record of Decision (ROD) is known as the Building 834 operable unit (OU) located at Lawrence Livermore National Laboratory (LLNL) Site 300, Tracy, California. This OU is designated as OU-2 in the Federal Facility Agreement (FFA) signed in June I992.

1.2. Statement of Basis and Purpose

This decision document presents the selected interim remedial action for the Building 834 OU at LLNL Site 300, Tracy, California. This remedial action was developed in accordance with the Comprehensive Environmental Response, Compensation and Liability Act-(CERCLA), as amended by the Supeffund Amendments and Reauthorization Act (SARA) and, to the extent practicable, the National Contingency Plan (NCP). This decision is based on the Administrative Record for this OU. The State of California Department of Toxic Substances Control (DTSC), Regional Water Quality Control Board (RWQCB), and the U.S. Environmental Protection Agency (EPA), Region IX, concur with the selected remedy.

The selected remedy set forth in this Interim ROD is intended only to address potential human inhalation risks resulting from volatilization of subsurface volatile organic compounds (VOCs). The following issues will be addressed in the Final (non-interim) ROD for the Building 834 operable unit:

1. Selection of supplemental innovative remedial technologies for remediation of subsurface dense nonaqueous phase liquid (DNAPL) and treatment of extracted soil vapor and ground water. These technologies have not yet been specifically identified, but will be evaluated concurrently with this interim action.

2. Ground water remediation strategy, ground water Applicable or Relevant and Appropriate Requirements (ARARs), and ground water cleanup goals.

3. Additional vadose zone remediation to protect ground water, if required.

4. Specific plans to monitor and protect the Tnbs1 regional aquifer.

5. Potential cumulative effects of multiple contaminants.

1.3. Assessment of the Site

Based on the baseline risk assessment, actual or threatened releases of hazardous substances at this OU, if not addressed by implementing the response actions selected in this Interim ROD, may present an imminent and substantial endangerment to public health and welfare, or the environment.

1.4. Description of the Selected Remedy

In June 1992, an FFA for the LLNL Site 300 Experimental Test Facility was signed by the U.S. EPA Region IX, DTSC, RWQCB, and the U.S. Department of Energy (DOE). The FFA (as

amended in 1995) defines seven OUs and designates the Building 834 OU as OU-2. The Building 834 OU is located on a north-south-trending ridge in the southeastern portion of Site 300. The OU was established to address soil and ground water contamination in the subsurface immediately beneath and approximately 1,500 ft downgradient of the Building 834 Complex. Presently, the Site 300 FFA is being amended and the total number of OUs may be reduced. The amendment process should be completed before December 1995, but is not expected to affect the Building 834 OU.

Interim actions for the Building 834 OU primarily target trichloroethylene (TCE) in shallow perched ground water and soil beneath the core of the Building 834 Complex: secondarily, they address contamination caused by other VOCs, diesel fuel, and tetra 2-ethylbutylorthosilicate (T-BOS). The primary potential risk associated with contamination at the Building 834 OU is on-site worker inhalation exposure to TCE volatilizing from contaminated subsurface soil (0.5-12.0 ft) in the vicinity of the release sites.

Current analytical data and ground water fate and transport modeling indicate that the regional aquifer will not be affected by any contaminants at the OU. DOE/LLNL will continue to monitor ground water in the perched water-bearing zone and regional aquifer.

The major components of the selected remedy include:

Installation of additional dedicated soil vapor monitoring points to monitor the progress of remediation.

Sealing and abandonment of several existing ground water monitor wells.

Installation of replacement ground water monitor wells.

Modification of ventilation systems in selected buildings to increase air circulation and reduce any potential inhalation risk from TCE vapors that may be migrating into buildings from subsurface soil.

Institutional exposure controls such as fences, warning signs, and excavation and/or construction restrictions, if required.

Surface water drainage controls, such as asphalt paving, to reduce recharge of precipitation to the perched water-bearing zone.

Light nonaqueous-phase liquid (LNAPL) extraction and treatment (T-BOS and diesel) to reduce the mass of these contaminants. Extracted LNAPLs will be removed from ground water using an oil-water separator, skimmer, or equivalent system.

Soil vapor extraction (SVE) and treatment. Extracted soil vapor will be treated using granular activated carbon (GAC) or other technology. The interim soil vapor restoration level (ISVRL) is 250 ppmv/v TCE, which corresponds to a TCE soil concentration of

2.2 mg/kg. Modeling indicates that this goal will be reached in approximately 5 years.

Partial dewatering of the perched water-bearing zone in the vicinity of the release areas to enhance the effectiveness of SVE by exposing a larger soil volume to vapor flow. Extracted ground water will be treated by a low-profile type (or similar type) air stripper with GAC emissions control. Treated ground water will be discharged through an air misting system. Effluent concentrations of TCE and total VOCs will meet the substantive requirements of the California RWQCB. Effluent will be treated below limits of detection established for EPA Methods 601 and 602. Effluent concentrations for total petroleum hydrocarbons (TPH) as gasoline, TPH as diesel, and T-BOS will also be set at concentrations agreed to by the regulatory agencies and DOE/LLNL. Because this Interim ROD addresses only soil vapor with respect to inhalation risk and NAPL remediation, it does not include any cleanup goals for in situ ground water in the perched

water-bearing zone or cleanup goals for soil and soil vapor to protect ground water; these goals will be addressed in the Final ROD.

Innovative technology development for enhanced removal of undissolved TCE DNAPL in the vadose zone and in shallow perched ground water. The objective will be to identify technologies that shorten cleanup time, improve cleanup efficiency, and reduce cost. Criteria to evaluate the effectiveness of any innovative technologies utilized will be developed with the regulatory agencies during the remedial design.

As presented in the Final Feasibility Study (FS) for the Building 834 OU (Landgraf et al., 1994) the 1994 present-worth cost of the selected remedy is estimated to be approximately $10.38 million. This estimate assumes 2 years of LNAPL recovery, 5 years of SVE and dewatering, and 30 years of soil vapor and ground water monitoring. These time and cost estimates do not include the development or testing of any innovative technologies.

During the June 23, 1994, Site 300 Remedial Project Manager's Meeting, DOE/LLNL, RWQCB, DTSC, and U.S. EPA agreed to pursue a remedial action alternative for the Building 834 OU that included the testing and evaluation of innovative technologies combined with SVE and dewatering. Because no proven technology is currently available to remediate subsurface DNAPL, DOE/LLNL will test innovative technologies under this interim action and may choose one or more to be implemented in the final remedy. Such technologies may include alcohol flooding, surfactants, dual-gas partitioning tracers, bioremediation, and in situ radio frequency heating.

During this interim action, DOE/LLNL may also test innovative treatment technologies to reduce waste mass, waste volume, and overall cost. Such technologies may include electron accelerator destruction, resin adsorption, and ozone treatment. Any testing and implementation of such technologies must be approved by the regulatory agencies.

As remediation progresses, soil vapor samples will be collected from SVE wells and soil vapor monitoring points. The remediation system will be shut down when no soil vapor sample exceeds the ISVRL concentration. Monitoring will be conducted for four consecutive quarters after ISVRLs are met. If soil vapor concentrations increase above an acceptable level, the SVE system will be restarted. In addition to the soil vapor sampling, DOE/LLNL may also conduct direct soil vapor flux and/or ambient air measurements during the interim action to verify that the

selected remedy is indeed protective of human health.

Prior to December 31, 1995, DOE/LLNL and the regulatory agencies will jointly determine the scope and schedule of all required post Interim ROD documents and reports (up to the Final ROD), as well as schedules for implementing the selected interim remedy.

1.5. Statutory Determinations

The interim action is protective of human health and the environment in the short term, and provides adequate protection until a final remedy for this OU is selected and presented in the Final (non-interim) ROD. The remedy complies with Federal and state applicable or relevant and appropriate requirements for this limited-scope action, and is cost-effective. Although this interim action is not intended to address fully the statutory mandate for permanence and treatment to the maximum extent practicable, it does utilize treatment; thus, it contributes to that statutory mandate. This action does not constitute the final remedy for the Building 834 OU. The statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element, although partially addressed in this remedy, will be addressed by the final response action. Subsequent actions are planned to address fully the threats posed by conditions at this OU. Because this remedy will result in hazardous substances remaining on site above health-based levels, a review will be conducted within 5 years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human

health and the environment. Because this is an Interim ROD, review of this site and of this remedy will be ongoing as DOE/LLNL and the regulatory agencies develop the final remedy for the Building 834 OU.

1.6. Signature and Support Agency Acceptance of the Remedy

<IMG SRC 0995141>

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Julie Anderson Date
Director of Federal Facilities Cleanup Office
Hazardous Waste Management Division
U.S. Environmental Protection Agency
Region IX

<IMG SRC 0995141A>

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Barbara Cook Date
Chief, Region II Site Mitigation Branch
State of California Department of Toxic Substances Control

<IMG SRC 0995141B>

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William H. Crooks Date
Executive Officer
State of California Regional Water Quality Control Board

Central Valley Region

<IMG SRC 0995141C>

_____

James M. Turner, Ph.D. Date
Manager
Oakland Operations Office
U.S. Department of Energy

2. Decision Summary

2.1. Site Name, Location, and Description

Site 300, a DOE-owned experimental test facility operated by LLNL, is located in the southeastern Altamont Hills of the Diablo Range, about 17 mi east-southeast of Livermore and 8.5 mi southwest of Tracy, California (Fig. 1). The site is bordered by cattle grazing land, a California Department of Fish and Game ecological preserve, an outdoor recreational facility, and a privately owned high explosives (HE) testing facility. For the purpose of this Interim ROD, it is understood that Site 300 will remain under the continued control of DOE for the foreseeable future.

The Building 834 operable unit (OU) is located on a north-south-trending ridge in the southeastern part of Site 300, and was established to address soil and ground water contamination in the subsurface below the facility (Figs. 2 and 3). However, to address potential
human inhalation risks, we discuss only soil remediation in this Interim ROD

2.2. Site History and Enforcement Activities

Prior to the purchase of Site 300 land for development as a DOE HE test facility, the Building 834 area was used for cattle ranching and livestock grazing. Since the late 1950s, the Building 834 facilities have been used to expose test specimens to thermal shock, thermal cycling, and long-term elevated or reduced temperatures.

TCE served as the primary heat transfer fluid for these operations until the entire system was
dismantled between September 1993 and May 1994. DOE/LLNL estimates that about
550 gallons of TCE, a suspected human carcinogen, leaked and spilled to the ground surface and a nearby septic system leach field, primarily between 1962 and 1978, contaminating the soil and shallow ground water in the area. Other chemical compounds commonly detected in the perched gound water in the Building 834 area include tetrachloroethylene (PCE), 1,2-dichloroethylene (DCE), 1,1,1-trichloroethane (TCA), T-BOS, and diesel fuel.

In 1982, DOE/LLNL discovered the contamination at the site and began an investigation under the guidance of the RWQCB. All investigations of potential chemical contamination at Site 300 were conducted under the oversight of the Central Valley RWQCB until August 1990, when Site 300 was placed on the National Priorities List (NPL). Since then, all investigations have been conducted in accordance with CERCLA under the guidance of three supervising regulatory agencies: the U.S. EPA Region IX, the RWQCB, and the DTSC. The DOE entered into an FFA with these agencies in June 1992.

In April 1994, LLNL released the Final Site-Wide Remedial Investigation (SWRI) report (Webster-Scholten, 1994). In July 1994, the Final Building 834 Operable Unit Feasibility Study

(FS) (Landgraf et al., 1994) was published. The SWRI and the FS form the basis for selecting technologies for the remediation of subsurface contamination at the Building 834 OU. The Proposed Plan (PP) for the remediation of the Building 834 OU, which summarizes site conditions and remedial alternatives, was released in December 1994. The public comment period on the FS and PP was conducted between January 9 and February 9, 1995.

Since the discovery of contamination at Building 834, some of the VOCs in the subsurface have been remediated by soil excavation, soil venting, and ground water extraction and treatment. In addition, this facility has already been used as a test bed for several innovative
technology treatability projects, including an EPA Superfund Innovative Technology Evaluation

(SITE) test of a PURUSTM pulsed ultraviolet soil vapor treatment system, an electrical soil heating pilot test (joule heating), and a demonstration of an electron accelerator to treat soil vapor
(Matthews et al., 1992).

2.3. Highlights of Community Participation

The SWRI report and the FS for the Building 834 OU were made available to the public in April 1994 and July 1994, respectively. The PP was released to the public in December 1994. This Interim ROD presents the selected remedial action for the Building 834 OU. All documents were prepared in compliance with CERCLA as amended by SARA. The decision for this site is based on the Administrative Record, which is available at the Information Repository at the LLNL Visitors Center and the Tracy Public Library.

A public review and comment period on the preferred remedial alternative began January 9, 1995, and ended February 9, 1995. Interested members of the public were invited to review all documents and comment on the considered remedial alternatives by writing to the Site 300 Remedial Project Manager or by attending a public meeting on January 24, 1995, at the Tracy Inn in Tracy, California. At this meeting, representatives from DOE, LLNL, U.S. EPA, and the State of California discussed the proposed remediation plan and addressed public concerns and questions. Questions and comments from the public are discussed in the Responsiveness Summary of this Interim ROD.

2.4. Scope and Role of the Building 834 Operable Unit (OU)

The 1992 FFA (as amended in 1995) defines the following seven OUs at Site 300:

OU-1, General Services Area (GSA).

OU-2, Building 834.

OU-3, Pit 6.

OU-4, High Explosives Process Area Building 815.

OU-5, Building 850/Pits 3 and 5.

OU-6, Building 832 Canyon.

OU-7, Site 300 Monitoring.

Investigations at the Building 834 OU address soil and ground water contaminated by VOCs, diesel, and T-BOS from past chemical spills and overfilling of an underground diesel storage tank. The principal potential threat to human health and the environment is exposure to VOC vapors volatilizing from shallow soil into ambient air.

This Interim ROD addresses only the potential human health inhalation risk posed by VOC contamination in the vadose zone at the Building 834 OU. The purpose of the selected remedy is to protect human health and the environment by reducing VOC concentrations in soil vapor and controlling contaminant migration.

2.5. Site Characteristics

Since environmental investigations began at the Building 834 Complex in 1982, 13 exploratory boreholes have been drilled and 48 ground water monitor wells have been completed. Two water-bearing zones have been identified (Fig. 4):

Perched Water-Bearing Zone: The small, shallow perched water-bearing zone occurs beneath the OU. Depending on topography, depth to water is approximately 10-70 ft

beneath the ground surface. As a result of past releases, this perched water is contaminated with TCE and other VOCs, diesel, and T-BOS.

Regional Aquifer: The regional aquifer occurs in the lower Neroly Formation (Tnbs1). This semi-confined aquifer is encountered at 325 ft below the ground surface.

The TCE plume in the perched water-bearing zone at the Building 834 OU is separated from the regional aquifer by over 280 ft of unsaturated bedrock. Data indicate that the perched zone contaminant plume has not affected the regional aquifer.

2.5.1. Chemical Releases

Historical information and analytical data suggest that VOCs and LNAPLs (diesel and T-BOS) were released to the ground from surface spills, discharges to a septic tank, and leakage from pipes, pumps, and valves between the early 1960s and mid-1980s. These releases include:

VOCs in the Building 834 OU near the core of the Building 834 Complex site and at the facility septic system. The quantity of TCE released in these areas greatly exceeds that of other VOCs. Based on employee interviews, we estimate that a total of about 550 gallons of TCE was released.

TCE at the decommissioned septic system leach field.

Diesel fuel in ground water attributed to accidental overfilling of an underground tank located near Building 834B.

T-BOS concurrently released with the TCE as a mixture. T-BOS is added to TCE-based heat exchange fluids to preserve pump seals.

2.5.2. VOCs in Ground Water

TCE is the most prevalent VOC in ground water within the perched water-bearing zone and perching horizon. Other VOCs that have been detected include PCE, cis-1,2-DCE, 1,1,1-TCA, acetone, benzene, chloroform, 1,1-DCE, ethylbenzene, Freon 113, methylene chloride, toluene, and xylenes (total isomers) (Table 1).

Figure 5 shows the distribution of TCE in perched ground water beneath the Building 834 OU. The width of the plume varies from about 200 ft at the southern end to about 500 ft in the area of the former septic system leach field. Perched ground water beneath the Building 834 OU is characterized as limited in extent, shallow (10-70 ft below ground surface), and relatively thin (2-5 ft saturated thickness). The eastern and western extent of TCE in

ground
water is limited by the extent of saturation in the perched water-bearing zone. The plume extends from the core area southward for about 1,500 ft. We estimate the volume of contaminated ground water to be 2,400,000 gallons.

Historically, the core area (Buildings 834B, C, and D) and former septic tank leach field area
have shown the highest concentrations of TCE in perched ground water. The maximum historical TCE concentration in the plume is 800,000 æg/L. This concentration suggests that TCE as residual DNAPL is present in the subsurface. The high TCE concentrations in ground water, soil, and soil vapor strongly suggest that TCE DNAPL may be present at and downgradient of the release sites. Environmental investigations conducted since 1982 indicate that the TCE ground water plume is of limited extent and relatively stable (i.e., not migrating downgradient) due to natural evapotranspiration. The shallow perched ground water at the Building 834 OU contains TCE and other chemicals of concern. Data indicate that shallow ground water is perched upon low-permeability siltstones and claystones, which prevent vertical migration to the semi-confined regional aquifer approximately 325 ft below the ground surface. No contamination from the perched water-bearing zone has been detected in the regional aquifer.

2.5.3. VOCs in Soil/Rock

Maximum TCE concentrations in borehole soil and rock samples are shown in Figures 6 and 7. TCE in vadose zone soil is mainly confined to the core area of the complex, near Buildings 834B, C, and D. The vertical and lateral variability of TCE concentrations in the core
area is attributed to multiple releases, release amounts, and release occurrences, as well as lithologic heterogeneity and the amount of time that has passed since the releases occurred. The
maximum concentrations of TCE in soil and rock mostly occur within 5 ft above or below the contact between the perched water-bearing zone and the perching horizon.

The maximum TCE concentration in soil (12,000 mg/kg) was detected in a soil sample collected in 1982 from a depth of 3.2 ft in the vicinity of a former TCE overflow drain behind Building 834C. At that time, TCE contaminated soil behind the building was excavated, aerated, and replaced with clean soil. The next highest TCE concentration (970 mg/kg) was found in the vicinity of Building 834D at a depth of 29.2 ft. Other than TCE, no other chemicals have been detected in soil and rock samples south of well W-834-T4.

Low concentrations of other VOCs reported in subsurface soil (0.5-12.0 ft) include PCE, Freon 11, benzene, ethylbenzene, toluene, and xylenes (total isomers) (Tables 2, 3, and 4). These
VOCs are detected in concentrations ranging from 0.0002 to 14 mg/kg, the highest being PCE in a shallow (< 5 ft) soil sample collected from behind Building 834D. PCE is common in soil and rock samples from wells adjacent to Building 834D and in the borehole for well W-834-J1; it has not been detected in soil samples collected south of well W-834-S5. Toluene, benzene, ethylbenzene, and xylenes (total isomers) have primarily been detected in soil samples collected tn the vicinity of Building 834D and the well W-834-T2 wells to the south. Freon 11 detection in
soil samples is mostly limited to low concentrations in the vicinity of Building 834D and the former septic tank leach field.

2.5.4. VOCs in Soil Vapor

Active vacuum induced soil vapor surveys (SVSs) were conducted between February and March 1989 to identify the extent of VOC contamination and to monitor the progress of vacuum extraction pilot studies (Fig. 8 and Table 5). The SVS sample results and the soil and rock

analytical data confirm that releases of TCE occurred adjacent to pump station Buildings 834B, C, and D.

2.5.5. Diesel in Ground Water and Soil/Rock

Diesel fuel detected in ground water and soil at the core of the Building 834 Complex is attributed to accidental overfilling of the underground diesel fuel tank. A TPH concentration of 100 mg/kg was detected at a depth of 20 ft in a soil sample from the borehole of well W-834-D8, located near the diesel tank. Maximum fuel hydrocarbon concentrations in ground water range from 25,000 to 73,000 æg/L, depending on the analytical method used.

2.5.6. T-BOS in Ground Water

T-BOS, a LNAPL, was mixed with TCE to lubricate and preserve the pump seals. This LNAPL has been observed floating in samples collected from well W-834-D3 and in the tank used to collect ground water during previous pilot testing of the remediation system near Building 834D. T-BOS may also be trapped in vadose zone and saturated zone soil pores.

2.6. Risk Assessment

The baseline risk assessment evaluated potential present and future public health and ecological risks associated with environmental contamination in the Building 834 OU, using the assumption that no cleanup or remediation activities would take place at the site. Selection of a specific remediation strategy is based in part on the extent to which it can reduce potential public health and ecological risks.

The baseline risk assessment presented in the SWRI consisted of six components:

Identification of the contaminated environmental media.

Identification of chemicals of potential concern.

Estimation of potential exposure-point concentrations of contaminants.

Human exposure and dose assessment.

Toxicity assessment.

Risk characterzation.

2.6.1. Identification of Contaminated Environmental Media

Based on our assessment of the nature and extent of contamination obtained during site characterization efforts, we identified contaminants of potential concern in four different environmental media in the Building 834 OU: surface soil, subsurface soil, soil vapor, and perched ground water.

2.6.2. Identification of Chemicals of Potential Concern

Table 6 presents the chemicals of potential concern identified in the Building 834 OU. Details of the methodology used to identify these contaminants are described in the SWRI.

2.6.3. Estimates of Exposure-Point Concentrations

We developed conceptual models to identify the probable migration processes of the chemicals of concern from release sites and source media in the Building 834 OU to selected potential exposure points. The conceptual models provided the basis for selection of the quantitative models used to generate estimates of contaminant release rates and potential exposure-point concentrations. The exposure-point concentrations were used to estimate the magnitude of potential exposure to contaminants in the baseline risk assessment. The release areas, migration processes, and exposure points identified in the Building 834 OU are given in Table 6. In addition, this table lists the mathematical models used to estimate contaminant migration rates and the potential exposure-point concentrations for the chemicals of concern in each environmental medium.

We applied a mathematical model to estimate the potential exposure-point concentrations of contaminants: 1) in the atmosphere when VOCs volatilize from subsurface soil (0.5 to 12.0 ft) in the vicinity of the Building 834D pump station, and 2) into indoor air of Building 834 when VOCs volatilize from subsurface soil underneath the building and diffuse into the building. A worst-case exposure scenario is assumed to occur in these locations because these are the regions for which the highest contaminant concentrations detected in subsurface soil have been reported.

In addition, we estimated the concentrations of surface soil (ó 0.5 ft) contaminants bound to resuspended particles throughout the OU. The potential exposure-point concentrations for direct dermal contact and incidental ingestion of contaminants in surface soil are the same as the 95% upper confidence limits (UCLs) of the mean concentration of the chemicals.

The California Department of Forestry well, CDF-1, located approximately 300 ft southeast of the Site 300 boundary, was selected as the receptor location for modeling of ground water contaminants that originate in the Building 834 OU. An analytic model was used to estimate the concentration of TCE in ground water predicted to reach the exposure point, well CDF-1.

2.6.4. Human Exposure and Dose Assessments

Exposure scenarios and pathway exposure factors (PEFs) used to define potential human exposure and dose assessments are described below.

2.6.4.1. Exposure Scenarios

The exposure scenarios that we used to evaluate potential adverse health effects associated with environmental contamination in the Building 834 OU were developed with respect to a series of assumptions about present and future uses of the site and lands in the immediate vicinity.

We developed two principal scenarios to evaluate potential human exposure to environmental contaminants in the Building 834 OU. The first of these scenarios pertains to adults working in the Building 834 OU. This scenario addresses potential health risks attributable to contaminants in subsurface soil and surface soil, where an adult on site (AOS) is presumed to work in the immediate vicinity of the contamination over their entire period of employment at the site (25 years). Subsurface soil contaminants can volatilize into the atmosphere, where they may be inhaled by individuals who work in the vicinity of the contamination. Surface soil contaminants bound to resuspended soil particulates may also be inhaled by individuals in the course of work-related activities at the site. In addition, we evaluated AOS exposure as a consequence of dermal

absorption and incidental ingestion of contaminants present on surface soil.

Our second scenario pertains to residential exposures (RES), which are associated exclusively with use of contaminated ground water from well CDF-1. The identification and selection of exposure pathways related to residential use of contaminated ground water were based on the assumption that well water will be used to supply all domestic water needs, such as those associated with showering or bathing, cooking, dishwashing, and laundry. Accordingly, are evaluated potential residential exposure to contaminants in ground water at CDF-1 due to 1) direct ingestion of water, 2) inhalation of VOCs that volatilize from water to indoor air, 3) dermal absorption of contaminants while showering or bathing, and 4) ingestion of aomegrown beef, milk, and fruits and vegetables raised using contaminated ground water. For the purpose of the risk assessment, we assume residents could be exposed to contaminants in ground water for 30 years.

2.6.4.2. Pathway Exposure Factors

To estimate the magnitude of potential human exposure to contaminants in the Building 834 OU, we developed PEFs, which convert the exposure-point concentrations of contaminants into estimates of average contaminant intake over time (the chronic daily intake or CDI). These PEFs are based on a series of reported and/or assumed parameters regarding current and potential land use patterns in and around the Building 834 OU, residential occupancy patterns, and length of employment. PEFs also account for a number of physiological and dietary factors such as the daily ingestion rates of water and homegrown fruits, vegetables, beef, and milk; daily breathing rate; and surface area of exposed skin.

The PEFs that we used to evaluate potential adult on-site and residential exposure to contaminants are presented in Tables 7 through 16.

2.6.5. Toxicity Assessment

For each location with environmental contamination, we began by identifying those chemicals of concern that are classified by the U.S. EPA as carcinogens (U.S. EPA, 1992c). This classification is based on consideration of data from epidemiological studies, animal bioassays, and in vivo and in vitro tests of genotoxicity. The three principal weight-of-evidence classifications are Group A (human carcinogen), Group B (probable human carcinogen), and Group C (possible human carcinogen). Placement of a chemical in Group A requires positive evidence of carcinogenicity from occupational or epidemiological studies. Such data are generally not available for chemicals classified as Group B or Group C carcinogens. For chemicals in these latter two groups, the preponderance of evidence of carcinogenicity typically comes from animal studies.

2.6.5.1. Cancer Potency Factors

The Cancer Potency Factors (CPFs) used in our estimations of cancer risk were obtained from values published in either the Integrated Risk Information System (IRIS) (U.S. EPA, 1992c), the Health Effects Assessment Summary Tables (HEAST) (U.S. EPA, 1992b,c), or by the State of California, Environmental Protection Agency (1992). We also had CPFs for TCE and PCE provided by Region IX of the U.S. EPA (1993). All CPFs were derived using versions of the linearized, multistage dose-response model (U.S. EPA, 1989a,b); generally, the dose- and tumor-incidence data used in the model are from animal bioassays. For contaminants of potential concern at Site 300, the exceptions are cadmium and beryllium, where human tumor data are available. The model calculates the potential increased cancer risk, where increased risk
is linearly related to dose for low-dose levels typical of environmental exposure. Use of animal
bioassay data to predict human tumorigenic response assumes that animals are appropriate

models of human carcinogenic response, and that the dose-response relationships observed in high-dose animal bioassays can be extrapolated linearly to the low doses generally associated with human exposure to environmental contaminants. When CPFs were available for a particular contaminant from both a U.S. EPA source and the State of California, we selected the highest potency from among the set of values.

The CPFs (slope factors) used to calculate cancer risks in our evaluation are presented in Tables 7 through 11.

2.6.5.2. Reference Dose

The reference doses (RfDs) that we used to evaluate potential noncarcinogenic adverse health effects were based, when possible, on long-term (i.e., chronic) exposures, and were derived by dividing an experimentally-determined no-observed-adverse-effect-level (NOAEL) or lowest-observed-adverse-effect-level (LOAEL) (each has units of mg/[kg d]) by one or more uncertainty factors (U.S. EPA, 1992b,c,d). Each of these uncertainty factors has a value that ranges from 1 to 10 (U.S. EPA, 1992b,c,d). We selected pathway-specific RfDs, when available (U.S. EPA, 1992b,c,d and Cal-EPA, 1992), to calculate a corresponding Hazard Quotient (HQ). If pathway-specific RfDs were not available, we used the published RfD (typically developed for oral exposures) to calculate an HQ for all exposure pathways.

The reference doses used to calculate noncancer hazard indices in our evaluation are presented in Tables 12 through 16.

2.6.6. Risk Characterization

The risk assessment was performed in accordance with Risk Assessment Guidance for Superfund (RAGS) (U.S. EPA, 1989a,b). Carcinogenic risks, an evaluation of potential noncarcinogenic exposure health hazards, and the additivity of response are described below.

2.6.6.1. Carcinogenic Risks

For carcinogens, we calculated the potential incremental cancer risk associated with long-term exposure to chemicals present in surface soil, subsurface soil, and ground water. For each chemical at each exposure location, the total risk attributable to that chemical was determined by multiplying each pathway-specific intake (e.g., the dose due to ingestion of water or to inhalation of contaminant that volatilizes from water to indoor air) by the corresponding pathway-specific CPF. The products of each pathway-specific intake and pathway-specific CPF were summed to obtain the potential incremental cancer risk for a specific chemical. We completed parallel sets of calculations for all chemicals at each exposure location, then summed values of chemical-specific risk from all chemicals present to yield an estimate of total incremental risk for exposures associated with a given location.

2.6.6.2. Evaluation of Hazard from Exposure to Chemicals that Cause Noncancer Health Effects

For chemicals of potential concern that are not classified as carcinogens, and for those carcinogens known to cause adverse health effects other than cancer, we evaluated the potential for exposure to result in noncarcinogenic adverse health effects by comparing the CDI with a RfD. When calculated for a single chemical, this comparison yields an HQ. For each chemical at which location, we summed pathway-specific HQs (where applicable) to obtain an HQ for a given chemical. We then summed all HQs from all chemicals to yield an HI for potential exposures associated with a given location.

2.6.6.3. Additivity of Response

In every location at or near the Building 834 OU where we calculated potential cancer risk and noncancer HQs, CDIs were estimated for exposures attributable to multiple pathways for each of several contaminants. As noted previously, we estimated the total potential cancer risk and/or total HI by summing risk or HQs for all contaminants at a given location, where each chemical-specific estimate of risk or hazard represents potential exposures from multiple pathways. Implicit in the summation of risk and hazard is the assumption that the effects of exposure to more than one chemical are additive. This simplifying assumption does not consider similarities or differences in target organ toxicity, mechanism(s) of action, or the possibility of synergistic or antagonistic effects of different chemicals in the mixture.

2.6.7. Summary of Baseline Risks and Hazards Associated with Contaminants

Baseline risks and hazards for the Building 834 OU were evaluated for adult on-site exposures, additive potential risk and hazard for adults on site, and residential exposures. These are described below, followed by a brief discussion of uncertainty.

2.6.7.1. Adult On-Site Exposures

We evaluated potential AOS exposure to this contamination by calculating the associated risk and hazard for two different scenarios: 1) inhalation of VOCs that volatilize from subsurface soil to the atmosphere in the immediate vicinity of the building; and 2) inhalation of VOCs that volatilize from subsurface soil underneath the building followed by diffusion int0 lhe building air. Both AOS exposure scenarios resulted in estimates of individual potential excess lifetime cancer risk (6 x 10-4 and 1 x 10-3) and noncancer HI (22 and 36) that exceed acceptable limits (U.S. EPA, 1990b).

Adults on site working in the Building 834 OU can potentially be exposed to contaminants present in surface soil. This exposure could occur if an individual inhales resuspended

contaminated particulates, comes in direct dermal contact with surface soil, or ingests small quantities of surface soil incidental to working in the area. Calculation of the risks associated with these exposures yielded estimates of total risk of 4 x 10-7 (inhalation of resuspended particulates) and 4 x 10-10 (ingestion and dermal absorption of surface soil contaminants). The corresponding total HIs are 7.2 x 10-5 and 1.1 x 10-2.

The calculations of potential cancer risk are presented in Tables 7 through 16 and the results are summarized in Tables 17 through 20.

2.6.7.2. Additive Risk and Hazard for Adults On Site

Adults working outdoors in the vicinity of Building 834D could be exposed simultaneously to contaminants present in surface soil (by inhalation of resuspended particulates, and ingestion and dermal absorption of surface soil contaminants) as well as by inhalation of the VOCs that volatilize from subsurface soil into the atmosphere in the immediate vicinity of Building 834D.

Table 21 presents the estimated potential additive risk and HI for this scenario, as well as the contributions attributable to each source or transport medium. The values given in Table 21

indicate an estimated total risk of 6 x 10-4 and a total HI of 22. Both the total risk and the total HI are dominated by contaminants present in subsurface soil near Building 834D and are not substantially affected by contributions to risk or HI from surface soil contaminants.

2.6.7.3. Residential Exposures

We evaluated potential residential exposure to contaminants in ground water at weir CDF-1 due to direct ingestion of water from the regional aquifer; inhalation of VOCs that volatilize from water to indoor air; dermal absorption of contaminants while showering or bathing; and ingestion of homegrown beef, milk, fruits, and vegetables raised using contaminated ground water. The calculations, presented in Tables 11 through 16 and summarized in Table 22, indicate the total potential excess lifetime excess cancer risk attributable to residential use of ground water is 7 x l0-11, and the corresponding total HI is 2.8 x 10-6.

2.6.7.4. Uncertainty in the Baseline Public Health Assessment

Uncertainties are associated with all estimates of potential carcinogenic risk and noncarcinogenic hazard. For example, the exposure parameters recommended by the U.S. EPA (1990a and 1991a) are typically obtained from the 90th or 95th percentile of a distribution; they are not necessarily representative of an average individual or of average exposure conditions. Consequently, use of upper-bound parameters may contribute to overly conservative estimates of potential exposure, and of risk and hazard.

2.6.8. Remedial Goals

To evaluate which remedial strategies would reduce potential public health risks in the Building 834 OU, we developed health-based PRGs. The baseline risk assessment identified subsurface soil/soil vapor in the vicinity of Building 834D as the only contaminated environmental medium in the Building 834 OU associated with an elevated risk or hazard. We applied the method presented in RAGS, Part B (U.S. EPA, 1991b) to derive health-based PRG concentrations which, if present in subsurface soil, would be protective of human health and the environment. The fundamental equation given in this method involves setting the total potential risk or hazard at a target level and solving for the concentration term. A concentration of 2.2 mg/kg TCE in soil is equivalent to an HI of 1. RAGS indicates that an HI greater than 1 may be associated with noncarcinogenic adverse health effects. The potential excess lifetime cancer risk associated with inhalation of TCE vapors, which volatilize from subsurface soil containing 2.2 mg/kg of TCE. is 3 x 10-5. For known or suspected carcinogens, acceptable exposure levels

are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10-4 and 10-6 using information between dose and response. The 10-6 risk level shall be used as the point of departure for determining remediation goals for alternatives when ARARs are not available or are not sufficiently protective because of the presence of multiple contaminants at the site or multiple pathways of exposure. The 10-4 to 10-6 risk range is generally acceptable for risk management decisions. The method, calculations and parameters used to derive the health-based PRG for the Building 834 OU are presented in the Building 834 FS. The range of health-based PRGs we calculated in our evaluation is presented in Table 23. This table also presents the preliminary remediation goals for TCE in soil proposed by Region IX, U.S. EPA (1994).

As shown in Table 23, the concentration of TCE in subsurface soil associated with an HI of 1 is 2.2 mg/kg. This concentration is lower than the U.S. EPA Region IX PRGs for both industrial

and residential soil (1994). To monitor the progress of subsurface soil remediation, we will analyze soil vapor samples from SVE wells and soil vapor monitor points, rather than attempting to collect soil samples. DOE/LLNL may also conduct direct soil vapor flux measurements in the future.

To convert a soil concentration of 2.2 mg/kg to a soil vapor concentration in ppmv/v, we use the following equations:

$$Cs\text{-}vapor = Cs \times \frac{1}{Kd} \times \frac{H}{RT} \times 103$$

where,

Cs-vapor = ISVRL-equivalent concentration of TCE in soil vapor (1.348 x 103 mg, $\frac{}{M3}$),

Cs = concentration of TCE in soil (2.2 mg/kg),

Kd = adsorption coefficient of TCE in soil (6.4 x 10-1 L, $\frac{}{kg}$),

H = Henry's Law constant (9.58 x 10-3 attm M3, $\frac{}{mole}$),

R = ideal gas constant (8.2 x 10-5 atm M3, $\frac{}{mole \quad degrees\ Kelvin}$),

T = temperature (298 degrees Kelvin), and

103 = conversion factor;

and,

$$Cs\text{-}vapor\ v/v = \frac{Cs\text{-}vapor \times 103 \times T \times R}{W \times P \times V}$$

where,

Cs-vapor v/v = ISVRL concentration of TCE in soil vapor (250 ppmv/v),

103 = conversion factor,

W = molecular weight of TCE (131.4 $\frac{g}{mole}$),

P = pressure (1 atm), and

V = volume (1 M3).

Thus, the ISVRL is set at a TCE concentration of 250 ppmv/v. The selection of an interim remediation goal for TCE alone was based on the observation that TCE is the principal subsurface contaminant and contributes approximately 90% of the total baseline risk. Possible cumulative effects from other contaminants will be addressed in the Final ROD for the Building 834 OU.

2.7. Description of Remedial Action Alternatives

The Feasibility Study for the Building 834 OU presented six alternatives to address VOC inhalation risks and to remove subsurface VOCs. Since migration of contaminated soil vapor from the vadose zone beneath the core of the complex may pose a threat to human health, its management and remediation were the focus of the FS. The six remedial action alternatives are summarized in Table 24.

2.7.1. Alternative 1-No Action

A no-action alternative is generally required as a basis from which to develop and evaluate remedial alternatives and is the postulated basis of the baseline risk assessment. Under a no-action response, all remedial activities in the Building 834 Complex would cease. However, the following activities would be performed:

Installation of ten dedicated shallow soil vapor monitoring points.

Installation of three additional ground water monitor wells.

Sealing and abandonment of two existing ground water monitor wells.

Monitoring, reporting, maintenance, database management, and quality assurance/quality control (QA/QC).

The present-worth cost of Alternative 1 is $4.19 million, which includes up to 30 years of soil vapor and ground water monitoring.

2.7.2. Alternative 2--Exposure Control

Alternative 2 focuses on 1) minimizing human exposure to inhalation of TCE and other contaminants evaporating from the subsurface, 2) reducing the potential for further contaminant mobilization in soil and ground water caused by infiltrating rain water, and 3)-reducing LNAPLs.

Alternative 2 includes:

All elements of Alternative 1.

Modification of building ventilation in selected buildings to provide increased circulation.
This would reduce the inhalation risk associated with exposure to indoor air.

Institutional exposure controls to reduce the health risk represented by exposure to VOCs within potential risk areas identified in the SWRI risk assessment. These measures would consist of fences, warning signs, and similar controls on site access and exposure.

Additional drainage controls, such as asphalt paving, along the perimeter of the Building 834 Complex core area. The objective would be to reduce recharge of water to the perched water-bearing zone.

LNAPL skimming and disposal to reduce LNAPL mass.

The present-worth cost of Alternative 2 is $5.69 million. This cost includes up to 2 years of
LNAPL recoved and up to 30 years of soil vapor and ground water monitoring.

2.7.3. Alternative 3--Source Mass Removal using SVE

The objective of Alternative 3 is to 1) reduce soil vapor VOC concentrations in the upper 12 ft of the vadose zone to health-risk-based concentrations (250 ppmv/v) associated with a total HI of 1, which corresponds to an excess potential cancer risk of 3 x 10-5, and 2) reduce LNAPLs. Alternative 3 consists of:

All elements of Alternative 2.

The institutional and exposure controls described in Alternatives 1 and 2, including additional ventilation to reduce potential exposure risks due to inhalation of VOC vapors.

SVE and treatment.

The present-worth cost of Alternative 3 is $8.72 million. This cost includes up to 2 years of LNAPL recovery, up to 5 years of SVE, and up to 30 years of soil vapor and ground water monitoring.

2.7.4. Alternative 4--Source Mass Removal using SVE and Dewatering

As with Alternative 3, the objective of Alternative 4 is to 1) reduce VOC concentrations in the vadose zone to health-risk-based concentrations associated with a total HI of 1, and 2) reduce LNAPL contaminant mass. The major components of Alternative 4 include:

All elements of Alternative 3.

Partial dewatering of the perched water-bearing zone to enhance SVE. Extracted ground water would be treated using an oil/water separator to remove LNAPLs, a low-profile tray (or similar type) air stripper, and a GAC vapor emissions control. Treated ground water effluent would be pumped to an effluent storage tank and later discharged on site through an air misting system to a sloped, undeveloped, grassy area east of the Building 834 Complex.

The present-worth cost of Alternative 4 is $10.38 million. This includes up to 2 years of LNAPL recovery, up to 5 years of SVE and dewatering, and up to 30 years of soil vapor and ground water monitoring.

2.7.5. Alternative 5--Source Mass Removal Using SVE and Ground Water Plume Control

As with Alternatives 3 and 4, the objective of Alternative 5 is to reduce VOC concentrations in the vadose zone to health risk-based concentrations and reduce LNAPL contaminant mass. Alternative 5 would include all of the elements for Alternative 4 and use additional dewatering at the Building 834 septic tank release area and the W-834-T2 and -T4 well cluster areas to provide downgradient VOC plume control and mass removal. The additional dewatering of the perched water-bearing zone would also reduce the potential for future plume migration by further reducing plume mass and volume, thus being slightly more protective of the environment. The major components of Alternative 5 include:

All elements of Alternative 4.

Downgradient ground water extraction for plume migration control.

The present-worth cost of Alternative 5 ranges from $11.80 million to $16.45 million depending on the duration of ground water extraction. This includes up to 5 years of SVE, between 5 and 30 years of dewatering (with up to 2 years of LNAPL recovery), up to 20 years of

soil vapor monitoring, and up to 30 years of ground water monitoring.

2.7.6. Alternative 6--Interim Source Mass Removal

As with Alternatives 3, 4, and 5, the objective of Alternative 6 is to reduce VOC vapor concentrations in the vadose zone to health-based concentrations associated with a total HI of 1, and reduce LNAPL contaminant masses near the release areas. Alternative 6 also adds DNAPL mass reduction via innovative technologies. The major components of Alternative 6 include:

All elements of Alternative 4.

SVE and treatment. Extracted soil vapor will be treated using GAC. The ISVRL goal is a TCE concentration of 250 ppmv/v in subsurface soil vapor. Modeling indicates that this goal will be reached in approximately 5 years.

Innovative technology development, testing, and application both for enhanced removal of undissolved TCE DNAPL in the vadose and shallow, perched water-bearing zones, and treatment of extracted soil vapor and ground water. The objective will be to identify technologies that shorten cleanup time, improve cleanup efficiency, and reduce cost.

The present-worth cost of the selected alternative is estimated to be approximately $10.38 million. This assumes up to 2 years of LNAPL recovery, up to 5 yearsof SVE and dewatering, and up to 30 years of soil vapor and ground water monitoring. These time and cost estimates do not include the development or testing of any innovative technologies.

Because no proven technology is currently available to remediate TCE DNAPL in the subsurface, DOE/LLNL will test innovative technologies, which may include alcohol flooding, surfactants, bioremediation, duatgas partitioning tracers, in situ radio frequency heating, resin adsorption, electron accelerator, and ozone treatment. The application of innovative technologies is extremely important in addressing subsurface DNAPL contamination. Analytical data strongly suggest that a volume of contaminant may be present as DNAPLs in the subsurface, and no DNAPL remediation systems currently exist. Three innovative technologies (alcohol flooding, surfactants, and dual gas partitioning tracers) are directly applicable to characterizing and/or remediating subsurface DNAPLs, and are currently under consideration. Descriptions of these technologies are presented in the FS.

2.8. Summary of Comparative Analysis of Alternatives

We have evaluated the characteristics of the six alternatives with respect to the nine EPA evaluation criteria:

Overall protection of human health and environment.

Compliance with ARARs.

Short-term effectiveness.

Long-term effectiveness and permanence.

Reduction of toxicity, mobility, or volume.

Implementability.

Cost-effectiveness.

Regulatory acceptance

Community acceptance.

DOE/LLNL and the regulatory agencies agree that Alternative 6 provides the best balance of trade-offs with respect to the evaluation criteria. Community acceptance is discussed in the Responsiveness Summary of this Interim ROD. In the following sections, Alternatives 1

through 6 are compared in relation to the remaining seven criteria. Table 25 summarizes this comparative evaluation with respect to all nine criteria.

2.8.1. Overall Protection of Human Health and the Environment

Alternative 1 does not actively remediate contaminated soil or ground water, which will not protect human health or the environment.

Alternative 2 protects human health inside the buildings by providing inhalation exposure controls. However, this alternative would not protect human health and the environment outside of the buildings because it does not remediate contaminated soil vapor or ground water.

Alternative 3 protects human health and the environment by using SVE to remediate contaminants in the shallow vadose zone and skimming to reduce LNAPL mass.

Alternative 4 protects human health and the environment by supplementing SVE with dewatering. This method would provide more efficient contaminant removal than Alternative 3 since a greater soil volume will be exposed for SVE by dewatering.

Alternative 5 supplements SVE and dewatering with more extensive ground water extraction, which would remove more subsurface contaminants more efficiently than Alternative 4. However, this alternative would not be more protective of human health and the environment than Alternatives 4 or 6 since there is no pathway that could result in
exposure to contaminants in the perched ground water.

Alternative 6 (the selected remedy) combines the elements of Alternative 4 with the testing and implementation of innovative technologies for DNAPL remediation. This alternative would be at least as protective to human health and the environment as Alternative 4 and may be more protective of the environment since innovative technologies may prove to be more effective at contaminant mass removal than SVE and dewatering alone.

9.8.2. Compliance with ARARs

Except for Alternative 1 (no action), all alternatives would meet all ARARs for this interim remedial action. DOE/LLNL is currently working with the Central Valley RWQCB to propose an amendment to the Basin Plan to exclude the perched water-bearing zone as a drinking water source because DOE/LLNL believes that the perched water-bearing zone does not meet State criteria with respect to water yield or natural quality (even without contamination). The Basin Plan currently defines the perched water-bearing zone as a potential drinking water source and, therefore, may require remediation of ground water to protect beneficial use. Such a requirement
may include remediation to background concentrations depending on technical and economic

feasibility. If the RWQCB grants an amendment, less stringent ground water cleanup criteria and soil cleanup criteria to protect ground water may be applied. Ground water remediation goals and soil remediation goals to protect water quality will be presented in the Final ROD for the Building 834 OU.

2.8.3. Short-Term Effectiveness

Alternative 1 does not remove significant quantities of VOCs from the subsurface. Therefore, this alternative would not be effective in short-term remediation of the site.

Alternative 2 removes only LNAPLs from the subsurface. Since this alternative does not reduce VOC mass, it would not provide short-term remediation of the site.

Alternative 3 uses SVE to immediately begin removing VOCs and reducing VOC soil vapor concentrations.

Alternative 4 combines SVE with dewatering to immediately begin removing VOCs and reducing VOC soil vapor concentrations. Dewatering would allow Alternative 4 to remediate a greater soil volume than Alternative 3.

Alternative 5 combines the elements of Alternative 4 with more extensive ground water extraction to immediately begin removing VOCs and reducing VOC soil vapor concentrations. This alternative would probably be as effective in the short term as Alternative 4.

Alternative 6 combines all elements of Alternative 4 with treatability testing of innovative remediation technologies. Innovative technologies may provide the greatest short-term effectiveness by removing higher quantities of contaminants than Alternative 4 or 5.

All alternatives would be protective of site workers and the community during the remedial action. No adverse environmental impacts are anticipated.

2.8.4. Long-Term Effectiveness and Permanence

Alternative 1 does not provide long-term effectiveness in meeting ISVRLs by not actively remediating contaminated soil and ground water.

Alternative 2 removes only LNAPLs from the subsurface. Since this alternative does not reduce VOC mass, it would not provide long-term effectiveness or permanence.

Alternative 3 uses SVE to provide long-term effectiveness through VOC mass removal and would permanently reduce VOC soil vapor concentrations to ISVRLs.

Alternative 4 combines SVE with dewatering to remediate a greater soil volume than Alternative 3 and would provide long-term effectiveness and permanence.

Alternative 5 uses SVE and more extensive ground water extraction to provide long-term effectiveness through mass removal and plume control, which would provide long-term effectiveness and permanence in reducing soil vapor concentrations of VOCs to ISVRLs.

Alternative 6 combines all elements of Alternative 4 with treatability testing of innovative remediation technologies. Innovative technologies may provide the greatest long-term effectiveness and permanence by removing higher quantities of contaminants than the technologies of Alternative 4 alone and, thus, are also more protective of the environment.

2.8.5. Reduction of Toxicity, Mobility, or Volume

Alternative 1 does not remove significant quantities of VOCs from the subsurface. Therefore, this alternative would not reduce toxicity, mobility, or volume of the VOCs.

Alternative 2 removes LNAPLs, but would not remove significant quantities of VOCs from the subsurface. Therefore, this alternative would not reduce the toxicity, mobility, or volume of the VOCs.

SVE and LNAPL recovery in Alternative 3 would significantly reduce the toxicity, mobility, and volume of contaminants in the subsurface.

By adding dewatering to SVE and LNAPL recovery, Alternative 4 would reduce the toxicity, mobility, and volume of contaminants in the subsurface more efficiently than Alternative 3.

SVE, dewatering, plume control, and LNAPL recovery in Alternative 5 would effectively reduce the toxicity, mobility, and volume of contaminants in the subsurface.

Alternative 6 would supplement the elements of Alternative 4 with innovative technologies, which may reduce the mobility, volume, and mass of VOCs, DNAPLs, and LNAPLs in the vadose zone and saturated zone more effectively than Alternative 4 alone. Because Alternative 6 will likely remove the largest amount of contaminant source mass, it is more protective of the environment and reduces future migration potential.

2.8.6. Implementability

Alternative 1 can be implemented easily with slight modifications to the existing ground water monitoring program.

Alternative 2 can be implemented using standard design and construction techniques and materials to modify building ventilation and surface drainage. Passive skimmers for LNAPL recovery are readily available, and DOE/LLNL has facilities to properly handle recovered LNAPLs as hazardous waste.

The SVE system and surface and drainage modifications of Alternative 3 are readily implementable. Major components of the remediation system are currently in place, and SVE, air stripping, and vapor-phase GAC are commercially available. However, SVE would involve some additional construction and long-term operation of remediation facilities.

The soil vapor and ground water treatment technologies incorporated into Alternatives 4 and 5 are readily available and many of the major components are already in place. These alternatives would involve some additional construction and long-term operation of remediation facilities in addition to the drainage control and ventilation projects. Phase separation, air stripping, and vapor-phase GAC are commercially available.

In Alternative 6, the soil vapor and ground water treatment technologies of Alternative 4 are combined with treatability testing of innovative technologies. Although the design of innovative technologies is difficult to predict, DOE/LLNL has the technical resources to implement each possible remedial alternative.

2.8.7. Cost-Effectiveness

The present-worth cost of Alternative 1 is $4.19 million for up to 30 years of soil vapor and ground water monitoring. This alternative has the lowest cost because it does not include remedial actions.

The present-worth cost of Alternative 2 is $5.69 million. This includes up to 2 years of LNAPL recovery and up to 30 years of soil vapor and ground water monitoring. Alternative 2 has a higher cost because it includes capital construction projects (drainage controls and ventilation retrofits) and ground water monitoring, but no remediation by long-term extraction and treatment.

The present-worth cost of Alternative 3 is $8.72 million. This includes up to 2 years of LNAPL recovery, up to 5 years of SVE, and up to 30 years of soil vapor and ground water monitoring. The higher cost of Alternative 3 is due to capital construction projects, as well as ground water monitoring and soil vapor treatment.

The present-worth cost of Alternative 4 is $10.38 million. This includes up to 2 years of LNAPL recovery, up to 5 years of SVE and dewatering, and up to 30 years of soil vapor and ground water monitoring. The dewatering and ground water treatment in Alternative 4 adds cost, so estimated total costs for this alternative are greater than for Alternative 3.

The present-worth cost of Alternative 5 ranges from $11.80 million to $16.45 million depending on the duration of ground water extraction. This includes up to 5 years of

SVE, between 5 and 30 years of dewatering, up to 2 years of LNAPL recovery, up to 20 years of soil vapor monitoring, and up to 30 years of ground water monitoring. The estimated total costs of Alternative 5 may be the highest because the duration of ground water extraction could be up to 30 years, compared to 5 years for Alternatives 3 and 4. In addition, this alternative requires a second ground water extraction and treatment system.

The total estimated cost of Alternative 6 is $10.38 million. Since costs and effects of innovative technologies are difficult to predict, their costs are not included in this estimate. However, if innovative technologies remove contaminants more efficiently than SVE and dewatering alone, site cleanup goals may be reached sooner and costs may be reduced.

2.9. Selected Remedy

DOE/LLNL, U.S. EPA, RWQCB, and DTSC agree that Alternative 6, which combines the treatability testing of innovative technologies with SVE and partial dewatering, would provide the best balance of trade-offs with respect to the CERCLA evaluation criteria. DOE/LLNL would begin subsurface remediation using SVE with dewatering to reduce potential risk and contaminant mass. During and/or following these actions, innovative remediation technologies would be applied and tested to enhance TCE DNAPL removal, and treatment of extracted soil vapor and/or ground water.

2.9.1. Treatment System Design

The majority of the risk reduction components are readily implementable with minor

modifications to the existing soil vapor and ground water extraction and treatment systems at the
core area of the Building 834 OU. The risk level for TCE is based on soil vapor exposure outside of Building 834D. The selected remedy targets a 3 x 10-5 cancer risk and an HI of 1 for an ISVRL for TCE of 250 ppmv/v, which corresponds to a soil concentration of 2.2 mg/kg.

The major components of the selected remedy include:

Installation of additional dedicated soil vapor monitoring points to monitor the progress of remediation.

Installation of additional ground water monitor wells.

Sealing and abandonment of several existing ground water monitor wells.

Modification of ventilation systems in selected buildings to increase air circulation and reduce the inhalation risk from TCE vapors that may be migrating into the building from subsurface soil.

Institutional exposure controls such as fences, warning signs, and excavation restrictions.

Surface water drainage controls, such as asphalt paving, to reduce recharge of precipitation to the perched water-bearing zone.

LNAPL (T-BOS and diesel) extraction and treatment. Extracted LNAPLs in well W-834-D8 will be removed using a passive skimmer. T-BOS from wells W-834-D3, -D4, and -D5 will be actively skimmed using a pneumatic pumping system. All recovered LNAPLs will be removed from the site by a licensed hauler and transported to a facility that has a Resource Conservation and Recovery Act (RCRA) permit for either incineration or recycling.

SVE and treatment (Fig. 9). DOE/LLNL will upgrade the existing SVE system at the Building 834 Complex to enhance its TCE removal capacity. New wells would be installed to provide additional locations for SVE. The locations of existing and proposed

SVE wells are shown on Figure 4-3 of the FS. Extracted soil vapor will be treated using GAC or other technology. The ISVRL TCE concentration is 250 ppmv/v, and modeling indicates that this goal would be reached in approximately 5 years. The SVE model used to estimate soil vapor cleanup time accounts for all possible phases, including DNAPL. However, it is possible that continuous volatilization of DNAPLs into the vadose zone could lengthen the actual cleanup time. Concentrations of contaminants in soil vapor would be monitored at dedicated soil vapor sampling points and at SVE wells for an agreed-upon period of time. If TCE concentrations increase above an acceptable level, the SVE system will be restarted.

Partial dewatering of the perched water-bearing zone to enhance the effectiveness of SVE by exposing a larger soil volume to vapor flow. Extracted ground water will be treated by a low-profile type (or similar type) air shipper with GAC emissions control, then discharged through an air misting system (Fig. 10). There is currently no specific cleanup goal for in-situ ground water in the perched zone.

Innovative technology development, both for enhanced removal of subsurface contamination and treatment of extracted soil vapor and ground water. The objective will

be to identify technologies that shorten cleanup time, improve cleanup efficiency, and reduce cost. Technologies to be tested may include, but are not limited to, alcohol flooding, surfactants, bioremediation, dual-gas partitioning tracers, in situ radio frequency heating, resin adsorption, electron accelerator, and ozone treatment. Three of these innovative technologies (alcohol flooding, surfactants, and dual-gas partitioning tracers) are directly applicable to characterizing and/or remediating subsurface DNAPLs, and are currently under consideration for the Building 834 Complex core area.

The Final ROD for the Building 834 OU will identify the selected remedial technologies Evaluation criteria will be developed to ensure that remediation is conducted as effectively and rapidly as possible. If monitoring indicates that the tested technology fails to meet the evaluation criteria, DOE/LLNL will meet with the regulatory agencies to discuss the implementation of another remedial alternative. If a tested technology successfully meets the established criteria, that technology will be permanently implemented as soon as possible.

Table 26 shows the current soil vapor and ground water monitoring program for the Building 834 OU.

2.9.2. Summary of Preliminary Cost Estimates

The 1994 present-worth cost of the selected remedy is estimated to be approximately $10.38 million as summarized in Table 27. This cost estimate assumes up to 2 years of LNAPL recovery, up to 5 years of SVE and dewatering, and up to 30 years of soil vapor and ground water monitoring. These time and cost estimates do not include the development or testing of innovative technologies. Cost estimates and equipment may change as the result of modifications during the remedial design and construction processes. Cleanup goals and length of cleanup time can be re-evaluated with the regulatory agencies every 5 years, based on the effectiveness of the remediation system, changes in site conditions, and changes in regulatory requirements.

2.10. Statutory Determinations

The selected interim response action for the Building 834 operable unit satisfies the mandates of CERCLA Section 121. The remedy will:

Protect human health by achieving the inhalation risk RAO for the operable unit.

Comply with ARARs (or justify an interim waiver).

Be cost effective.

DOE/LLNL, U.S. EPA, RWQCB, and DTSC believe that among the six proposed remedial alternatives, Alternative 6 provides the best balance of trade-offs with respect to the CERCLA evaluation criteria. Site 300 will remain under the control and ownership of DOE for the foreseeable future. This relationship is a major factor in defining the scope of the remedy proposed in this Interim ROD. A brief description of how the selected remedy satisfies each of these statutory requirements is provided below.

2.10.1. Overall Protection of Human Health and the Environment

Potential elevated health risks result from VOC contamination in vadose zone soil vapor between 0--12 ft beneath the core of the Building 834 Complex. SVE with dewatering and

LNAPL recovery will be used during or post-surfactant injection to reduce the volume and toxicity of the contaminants and limit VOC migration. All emissions and ground water will be treated before discharge to the environment. Soil vapor and ground water monitoring will document the progress and permanence of all remediation methods.

Based on the chemicals of concern, exposure routes, potential receptors, and the findings of the baseline risk assessment, the potential excess cancer risk remediation goal for soil vapor is
3 x 10-5, based on achieving an HI of 1.

Innovative remedial technologies will be implemented and tested at the site. DOE/LLNL plans to begin this effort by testing surfactant injection, which should increase the solubility of
DNAPLs and LNAPLs and increase contaminant recovery rates. In addition, protection of human health will be ensured by improving ventilation in Buildings 834A, D, J, and O, and restricting site construction and access. Surface drainage improvements in the Building 834 Complex area will reduce infiltration and subsequent migration of contaminants from the source areas.

In accordance with a DOE Secretarial Policy issued in June 1994, NEPA values contained in the Environmental Considerations chapter of the FS satisfy the requirements for CERCLA-NEPA integration. As part of these requirements, we evaluated the potential impacts on the existing on- and off-site environment due to implementation of the remedial alternatives. No significant adverse impacts due to implementation of the alternatives were identified.

2.10.2. Compliance with ARARs

Federal and state chemical-, location-, and action-specific ARARs affecting the selected interim remedy are described in Table 28. The selected remedy meets all ARARs. DOE/LLNL is currently working with the Central Valley RWQCB to propose an amendment to the Basin Plan to exclude the perched water-bearing zone as a drinking water source because it does not meet State criteria with respect to water yield or natural quality (even without contamination). The Basin Plan currently defines the perched water-bearing zone as a potential drinking water source and, therefore, may require remediation of ground water to protect beneficial use. Such a
requirement may include remediation to background concentrations depending on technical and economic feasibility. If the RWQCB grants the amendment, less stringent ground water cleanup criteria may be applied. Ground water remediation goals will be presented in the Final ROD for the Building 834 OU.

2.10.3. Utilization of Permanent Solutions and Alternative Treatment Technologies

The selected remedy provides long-term effectiveness through mass removal, which will reduce VOC soil vapor concentrations to ISVRLs and acceptable health risk levels. The selected remedy will test, implement, and evaluate promising innovative remedial technologies aimed at DNAPL removal and extracted water and vapor treatment to the fullest extent practicable.

2.10.4. Reduction of Toxicity, Mobility, or Volume as a Principal Element

Contaminant toxicity, mobility, and volume in the soil and ground water will be reduced irreversibly by SVE, dewatering, and LNAPL recovery. Innovative technologies may significantly reduce the toxicity, mobility, and volume of DNAPLs in the subsurface, enhance the progress of VOC removal, and be more protective of the environment. SVE and dewatering will reduce the volume and concentration of contaminants in the subsurface; however, without DNAPL removal, subsurface concentrations of TCE could rebound after SVE is discontinued.

2.10.5. Cost Effectiveness

DOE/LLNL, U.S. EPA, RWQCB, and DTSC agree that Alternative 6 is the best value since this remedial alternative provides the opportunity to test and implement innovative technologies that may prove to be more efficient and cost-effective than the currently available technologies.
Each alternative was costed on the basis of a design to reduce inhalation risks and provide source
mass removal of contaminants, to prevent emissions of VOCs to the air, and to treat waste water to a TCE concentration <0.5 ug/L (Fig. 11).

3. Responsiveness Summary

This section responds to public comments directed to DOE, LLNL, U.S. EPA, and the State of California regarding the Proposed Plan (PP) for the remediation of the Building 834 Operable Unit (OU). Responses to community comments and concerns are incorporated into this Interim ROD.

The public comment period on the PP began January 9, 1995, and ended February 9, 1995. On January 24, 1995, DOE/LLNL and the regulatory agencies held a public meeting'at the Tracy Inn in Tracy, California to present the proposed remediation plan and allow the public to ask questions and comment on the preferred remedial alternative. After representatives from LLNL summarized the information presented in PP members of the public directed questions to a panel of DOE, LLNL, and regulatory agency representatives. Following the question-and-answer session, three members of the public read their concerns into the formal public record. Although
no letters were received during the PP comment period, members of the Tri-Valley Citizens Against a Radioactive Environment (CAREs) provided a written record of their meeting comments and additional comments that were not presented at the meeting. The meeting transcript and a copy of the written concerns are available to the public at the LLNL Visitors Center and the Tracy Public Library.

3.1. Organization of the Responsiveness Summary

The Responsiveness Summary is organized to clearly present the breadth of public concerns while avoiding repetition. In keeping with EPA Superfund guidance and common accepted practice, comments are grouped by subject. If two or more comments are identical or similar, only one response is provided. Whenever possible, comments are summarized verbatim from either the meeting transcript or written comments.

Public comments are grouped into the following sections:

Selected Remedial Action.

Protection of the Environment.

Impact of Future Activities.

Community Relations.

General Comments.

3.2. Summary of Public Comments and Responses

3.2.1. Selected Remedial Action

Comment 1:

One of the things that needs to be stated clearly and unequivocally is that the levels of contamination both at Building 834 area and Site 300 in general are extremely high. I've worked in monitoring cleanups at other facilities and these, you know, numbers like 800,000 parts per billion TCE. I mean, that's not a number you see very often. And the tritium peaking at eight hundred thousand picocuries per liter with current concentrations of a least 300 thousand picocuries per liter. So this is a very serious cleanup even though the area is more remote, say, than the main site. The contaminant levels are themselves a concern. At that level,

we suspect that there is probably free product sinking in terms of the TCE contamination that will complicate the cleanup. That needs to be considered.

Response 1:

Remediation of the perched water-bearing zone and standards for ground water cleanup will be discussed in the Final ROD. Although the perched ground water contains VOCs, this ground water does not pose a risk to human health or the environment because there are no exposure pathways. Since migration of contaminated soil vapor from the vadose zone beneath the core of the Building 834 Complex may pose a threat to human health, monitoring, management, and remediation are the purposes of the selected interim remedial action.

DOE/LLNL and the regulatory agencies agree that the selected interim remediation decisions made for this site will mitigate the potential human health inhalation risk associated with the Building 834 OU. We agree that TCE as free product probably exists as residual DNAPL in the subsurface. This is a primary driver for the inclusion of innovative technologies in the selected
remedy. The high concentrations of VOCs in ground water will be addressed in the Final ROD. No cleanup goals for ground water are presented in this Interim ROD.

There was no tritium used, nor has any tritium contamination been detected, in the Building 834 OU.

Comment: 2

The cleanup standard chosen for Volatile Organic Compounds in soil (2.2 mg/kg or 250 ppmv/v in soil vapor) appears to be set too high. We note that in the South Bay, industry is
asking for a standard of 0.5 mg/kg. Moreover, the cleanup standard assumes an occupational standard in industrial use of Building 834. While this assumption may be reasonable in the short
term, given the uncertainties of funding for Lab activities, we believe a more conservative standard should be analyzed. Our position is supported by EPA OSWER Directire 9355.0-30, Role of the Baseline Risk Assessment in Superfund Remedy Selection Decision, April 1991. On page 5, EPA states, "both current and reasonable future risks need to be considered..." based on an assumption of future land use different from that which currently exists. The potential land use "associated with the highest level of exposure and risk..." should be used in developing remediation objectives. Further, the National Contingency Plan states that EPA will consider future land use as residential in many cases, "and undeveloped areas can be assumed to be residential in the future unless sites are in areas where residential land use is unreasonable."

We do not believe that LLNL has made any showing that future residential land use either upon or abutting Site 300 is an unreasonable scenario. Therefore, if the assumption concerning reasonable land use yields a stricter cleanup standard, we want the Lab to commit to this

stricter
standard, should land use assumptions change.

Response 2:

The ISVRL was developed by modeling potential TCE vapor inhalation risks. The concentration of TCE in subsurface soil associated with this ISVRL is an HI of 1 and a potential excess lifetime cancer risk of 3 x 10-5. The regulatory agencies concur with this ISVRL cleanup goal.

These standards do not address the potential for soil vapor to contaminate ground water. However, the TCE concentrations in perched ground water exceed the level that could be caused by soil vapor contamination alone. Given the concentration of VOCs in ground water, VOCs could volatilize into the vadose zone.

DOE is committed to maintaining stewardship of LLNL Site 300 for the foreseeable future, and plans to continue operations at the site in support of national security programs and other activities of national interest. In so doing, Site 300 and the Building 834 OU will remain inaccessible to the public by the use of security fences and protective surveillance.

The maintenance and mission of Site 300 depend on Congressional funding decisions. If the U.S. Congress decides to terminate or modify operations at Site 300, DOE (or its successor agency, if appropriate) would manage an orderly shutdown of the facility, which would include a reassessment of cleanup standards. The Interim ROD would be modified to reflect changes in land use that could potentially affect site remediation.

Comment 3:

We are deeply concerned that there is no ground water standard for the perched aquifer. While we understand that the Lab is applying for a variance from the State classification as a potential drinking water source, we believe that the ground water should be cleaned up at least to the Maximum Contaminant Level or to a standard which will not incur an Incremental Lifetime Cancer Risk higher than one in a million. The documentation which clearly lays out how this standard will be met should be identified. In this context, we note that there is some evidence the perched aquifer may have been much larger in the past. It is at least possible the "mystery" source of contamination in the Building 833 area could have been the perched aquifer. So we have concerns regarding the Lab's request to delist this aquifer from State waters.

Response 3:

As stated in Response 1, remediation of the perched water-bearing zone will be addressed in the Final ROD. Although the perched ground water contains VOCs, this ground water does not pose a risk to human health or the environment because there are no exposure pathways. Because migration of contaminated soil vapor from the vadose zone beneath the core of the Building 834 Complex may pose a potential threat to human health, the selected interim reinedial action has been formulated to monitor, manage, and remediate the contamination.

Under the current Basin Plan, the Central Valley RWQCB considers the perched water-bearing zone a potential drinking water source, a potential receptor, and a possible source and pathway for contaminants to reach the regional aquifer. However, DOE/LLNL is presently working with the Central Valley RWQCB staff to propose an amendment to the Basin Plan to exclude the perched water-bearing zone as a drinking water source. DOE/LLNL believe the existing field and analytical data indicate that the perched water-bearing zone does not meet criteria contained in State Water Resources Control Board Resolution 88-63 (Sources of Drinking Water Policy) with respect to water yield or natural quality (even without contamination). They further believe that the perched water-bearing zone does not provide a

pathway for contaminants to reach the regional aquifer. In addition, DOE/LLNL believe that existing hydraulic and analytical data provide significant evidence of the impermeable nature of the perching horizon and the lack of hydraulic communication with the regional aquifer. They will include this information in the proposed amendment.

The Basin Plan currently defines the perched water-bearing zone as a potential drinking water source and, therefore, may require remediation to protect beneficial use. Such a requirement may include remediation to background concentrations or to MCLs, if it is technically or economically infeasible to achieve background concentrations. If the RWQCB grants the amendment, less stringent in-situ ground water cleanup criteria may be applied, but additional ground water remedial actions, including but not limited to additional soil source control, will still need to be considered. Cleanup goals for the perched ground water-bearing zone will be developed and presented in the Final ROD.

Comment 4:

That plume, as you may recall from the presentation this evening, 1,500 feet long, about 500 feet wide, as I recall, of the perched water -- and supposedly it sits on top of this clay,

impervious clay, which we might conclude as, well, why not just let it sit there and do nothing about it? We feel that this is important to continue that procedure of getting rid of that water.

Response 4:

Because ground water cleanup standards have not yet been established, remediation of the perched water-bearing zone will be addressed in the Final ROD. However, the interim action includes dewatering, which will remove and treat significant amounts of perched ground water.

Comment 5:

Referring to p. 1-18 and p. 1-21 (of the FS), please explain what appears to be incongruous findings: first, that it is estimated that 540 gallons of TCE was released in the vicinity of Building 834 over 16 years; and, second, that there were recent TCE concentrations in ground water up to 800,000 æg/L (ppb).

Response 5:

Historical information and analytical data presented in the SWRI and FS indicate that approximately 550 gallons of VOCs, primarily TCE, were released at ten locations at the Building 834 Complex between the early 1960s and early-1980s. Some of the VOCs eventually migrated to the perched water-bearing zone, which caused the ground water to contain TCE concentrations as high as 800,000 ppb. The estimated volume of TCE spilled is consistent with TCE concentrations in ground water.

The volume of TCE in soil was estimated to be 270 gallons for the soil vapor modeling presented in Appendix F of the Final Feasibility Study (FS) for the Building 834 Operable Unit (Landgraf et al., 1994). Mass estimates of TCE in ground water are approximately 800 lb (roughly 70 gallons). These estimates are uncertain due to the undocumented volume of VOCs released, significant subsurface lithologic heterogeneity, limited soil analytical data, variable
saturated thickness, and variable VOC concentrations in ground water and soil. As such, these estimates are subject to change with additional information.

Comment 6:

Before the plan is approved (e.g. by the community) it is important the monitoring plan be

specified (e.g. number of wells, depth of wells, frequency of sampling, duration of sampling, location of wells etc.) and a contingency plan be specified which delineates what the Lab is committed to do in the event it finds the plume is moving, or is not being remediated in the time-
frame or to the extent expected.

Response 6:

A preliminary monitoring plan was presented in the FS primarily to support cost estimates for each remedial alternative. Consistent with the procedures at other U.S. EPA Superfund sites, the monitoring program will be presented in the Remedial Design/Remedial Action documents.

Because the selected remedy results in contamination remaining on site (i.e., not immediately
remediated or removed), the agencies are required to review the progress of remediation at least every 5 years to ensure that the selected remedy is effective and continues to adequately protect
human health and the environment. Progress of site cleanup will be published in periodic progress reports. If monitoring data indicate that the selected remedy is not effectively remediating the site, DOE/LLNL and the regulatory agencies will discuss implementing another remedial alternative

Comment 7:

The Feasibility Study (FS) and/or subsequent primary documents should contain milestones by which the success of the remediation can be evaluated. The remedy and accompanying plan should contain firm commitments. It is important to community acceptance that the FS and

subsequent plans contain a measurable schedule and performance standards which can be verified. Commitments as to the timing of cleanup activities can and should be spelled out.

Further, we recommend two sets of milestones be codified: contaminant milestones and mass removal milestones. Contaminant milestones would require the Department of Energy and the Lab to set timed goals for incrementally reducing the concentration of VOCs in soil and ground water. Mass removal milestones would the removal of a specified volume of contamination during a specified time period. Five year goals should be spelled out in the Interim ROD and/or other appropriate document(s).

Response 7:

Consistent with U.S. EPA Superfund site procedures and as specified by the CERCLA process, schedules and performance milestones will be presented in design documents.

Every 5 years, the regulatory agencies will review the progress of remediation to ensure that
the remedy is effective and continues to provide adequate protection of human health and the environment. Reports on the site cleanup will be published.

If the selected remedy fails to meet the criteria set forth in the design documents, DOE/LLNL
and the regulatory agencies will discuss implementing another remedial alternative.

Comment 8:

With regard to the Building 834 complex, the problems there that we have in soil and groundwater are not unique to Californians. It's in the Silicon Valley. It's everywhere. We got

chlorinated solvents in soil and ground water. Big problem.

What is unique about the Building 834 complex is we got this little perched aquifer up on a hilltop isolated from the regional aquifer, at [a 280 foot] separation. This has created an opportunity for the Department of Energy. There's letters from the State Water Resources Control Board which support the Lawrence Livermore and DOE to proceed with testing innovative technologies for the remediation of solvents, free-phase solvents (DNAPLs).

It gives us an opportunity to test and search out technologies which will, if proven, will go into other areas like Silicon Valley, wherever we have these big spills, and accelerate those cleanup efforts.

So I just wanted to get it on the record here that I think that the Regional Board has come out in support of the innovative technology approach to the 834 complex. I know that the State Water Resources Control Board has come out in support of that concept.

Response 8:

DOE/LLNL, U.S. EPA, RWQCB, and DTSC agree that the development, testing, and evaluation of innovative technologies have several advantages. Innovative technology testing at Building 834 may expedite remediation, and the successful new technologies could be valuable to other sites, especially where public exposure risks are a greater issue.

Comment 9:

Criteria should be established by which to judge whether to go ahead with an innovative technology after a treatability study. That criteria should be set forth in the FS, and/or other appropriate documents in case a new technology has only partial success.

Response 9:

Criteria for evaluating a remedial alternative will be established during the treatability study for each technology being tested.

The effectiveness of new technologies will only be known after the technologies have been implemented in the field and their effects are monitored. The remedy selected will be optimized

as monitoring data warrants, to make sure that the remediation is conducted as effectively and quickly as possible.

Comment 10:

Referring to Appendix E (of the FS), discussion of resin adsorption-regeneration--although this technology has theoretical advantages for treating off-gas from soil vapor extraction, tests of the Purus Padre system at McClellan AFB have been disappointing. The Air Force is thinking of retesting an improved version at AF Plant 44 in Tucson, Arizona. I strongly recommend that the Lab investigates the McClellan results (contact Bud Hoda) before it invests in this technology.

Response 10:

LLNL's initial efforts to reach Bud Hoda were unsuccessful. However, LLNL has already investigated resin-adsorption regeneration and believes that it is an appropriate and effective technology. If DOE/LLNL proposes to apply this remedial technology at Building 834, LLNL will carefully review its application at other sites and modify the system, if necessary, to optimize its effectiveness.

3.2.2. Protection of the Environment

Comment 11:

We are concerned that there is not sufficient information to state with certainty that the regional aquifer has not been contaminated.

Response 11:

Since studies began at the Building 834 Complex in 1982, 13 exploratory boreholes have been drilled, and 48 ground water monitoring wells have been installed. Hydraulic tests have been performed on wells in the Building 834 Complex to determine the hydraulic characteristics of the hydrologic units and to define hydrostratigraphic relationships. For example, neutron logging of several deep monitor wells has indicated that the 280 ft of bedrock between the perched zone and the regional aquifer is unsaturated. The results of these tests are summarized in the F.S.

DOE/LLNL, U.S. EPA, RWQCB, and DTSC agree that information gathered during site investigations supports the conclusion that the TCE plume in the perched water-bearing zone has not contaminated the regional aquifer.

However, if high concentrations of contaminants are to remain in the perched water-bearing zone, evidence of the impermeable nature of the perching horizon and lack of hydraulic communication with the regional aquifer will need to be cited in the proposed Basin Plan Amendment. Remediation decisions regarding the perched ground water will be included in the Final ROD to the Building 834 OU.

Comment 12:

Referring to page EX-5, please explain in detail how the results of this FS do not have adverse effects in the context of NEPA. Opportunities for on-site and nearby off-site activities
will be foreclosed by adoption of the proposed cleanup standard (based on industrial use scenario).

Response 12:

The purpose of the FS was to develop and evaluate alternatives for remedial action at the Building 834 OU in accordance with CERCLA/SARA and the National Environmental Policy Act (NEPA). Specifically, Chapter 6 of the Building 834 FS provides a detailed NEPA evaluation of potential impacts on the existing on-site and off-site environment due to

implementation of the remedial alternative. No significant adverse impacts due to implementation of the alternatives were identified.

Comment 13:

In many Superfund cleanups, a principal is established that does not permit drawing contaminated ground water through less contaminated soil or ground water. We recommend this principal be adopted at Site 300.

Response 13:

The selected remedy does not involve drawing contaminated ground water through less contaminated soil or ground water. We agree that the principal mentioned in the comment is sound practice.

3.2.3. Impact of Future Activities

Comment 14:

We are concerned about the potential for additional contamination stemming from some current and future activities proposed at LLNL's Site 300, such as:

Increased hydrotesting activities (implosion of bomb cores using surrogates for plutonium such as uranium 238, and possibly involving tritium as well)

Increased high explosives manufacturing activities

The possibility that Site 300 will be chosen as the nuclear weapons complex's mixed waste dump site.

Response 14:

These issues are beyond the scope of remediation at the Building 834 OU.

Comment 15:

It is reasonable to assume that Building 834, and/or its associated buildings, will be demolished at some fitture date (perhaps to be replaced by an industrial building). We would like to see included in the risk-based standard such factors as demolition, disposal of soil and demolition debris, and the effects of soil/vapor exposure on demolition and construction workers.

Response 15:

If LLNL decides to demolish buildings at the Building 834 complex, the risks associated with demolition, disposal of soil and demolition debris, and the effects of soil/vapor exposure on demolition and construction workers will be evaluated. After completing a risk assessment, a site safety plan would be written that would summarize site hazards and establish the levels of personal protective equipment required for demolition and construction workers. LLNL's decommissioning and decontamination activities take place under strict operating procedures which ensure that soil and building debris will be decontaminated and disposed of properly.

3.2.4. Community Relations

Comment 16:

We, the public, have the right to monitor the cleanup. The environment does not belong to the Department of Energy. It belongs to us and our children for seven generations into the future.

Response 16:

DOE/LLNL is committed to providing opportunities for community involvement in the project. The community will be able to monitor and participate in the cleanup process

Comment 17:

I think we're concerned because there has been a tendency to discount or to indicate to the public that there is no need to be concerned. So many times yet we know that there has -- and this is -- in many cases, there's a difference of opinion among qualified scientific authorities,
whether a low level of radiation, for example, is a hazard or not.

Response 17:

Cleanup standards for the Building 834 OU will be based on the best available scientific data,
and will meet or exceed environmental and public protection standards. The 250 ppmv/v ISVRL was developed by modeling potential TCE vapor inhalation risk. This vapor concentration correlates to a soil concentration of 2.2 mg/kg and an HI of 1. The regulatory agencies concur with the ISVRL.

We have no evidence that radioactive materials have been released to the environment at the Building 834 OU.

3.2.5. General Comments

Comment 18:

Tri-VaIley CAREs has three over-arching goals in terms of monitoring and participating in decision making in the Site 300 cleanup.

One is to ensure the most thorough cleanup possible. Secondly, to ensure that the technologies that are chosen to clean up the site are themselves protective of human health and the environment. And third to facilitate public involvement in decision making in all aspects of
the cleanup.

I really appreciate over the last couple of weeks that the Laboratory has done briefings for our organization. We recently received the technical assistance grant to help get us up to speed
quickly on this aspect of the cleanup, and a public meeting was coming down the pipe almost immediately.

And it is unfortunate that this public meeting is not only the same day as the State of the Union address, but also the same day as the public meeting 15 miles away on another laboratory matter which is also important to the public. I do understand that you folks chose the date first,
and I will put that on the record.

Response 18:

Comments noted.

Comment 19:

The Department of Energy must commit in writing to provide adequate, stable, long-term funding for this cleanup.

Parenthetically, because the Lawrence Livermore Lab is a Department of Energy facility, cleanup funds must come directly from the Department of Energy, not the Environmental Protection Agency's Superfund account. The Department of Energy has a history of moving money from its cleanup accounts into its weapons programs.

Response 19:

DOE cannot legally commit to funding cleanup or any other activities beyond the current budget year appropriation. However, DOE places a high priority on risk reduction, compliance, and associated contamination cleanup in its annual budget submittals. DOE understands that cleanup delays will likely increase the overall cost of the cleanup at LLNL as well as other facilities, so it is in DOE's best interest to support an adequately funded and progressive cleanup
effort through its annual Congressional budget request each year. DOE does commit to request from Congress through the Office of Management and Budget funding necessary to control and remediate contaminant plumes, both on and off site. In addition, DOE is also committed to removing contaminants as efficiently as possible using available technologies within budgeting allocations.

DOE is not currently authorized to establish special funds for specific projects such as environmental restoration. The comment is correct that cleanup funds for the Building 834 OU are from DOE, not the Superfund account. Congress is the only government body that can approve reprogramming and appropriation transfers between weapons design, production, and testing work (as well as other program work) and environmental restoration work. If such a transfer should occur, it is DOE's responsibility to ensure that compliance with environmental regulations is maintained, or that funding be reallocated within available funds, or to request supplemental funding from Congress, if necessary.

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Tables

UCRL-AR-119791 Interim ROD for the Building 834 Operable Unit, Site 300 1995

Table 1. Contaminants of potential concern in ground water in the Building 834 operable unit.e

Contaminant	Maximum concentration æg/L (ppb)	Mean concentrationa	95% UCLb æg/L (ppb)
1,1,1-Trichloroethane	3.3 x 104	3.02 x 103	1.87 x 104
1,1-Dichloroethylene	9.0 x 102	2.10 x 101	8.47 x 101
cis-1,2-Dichloroethylenec	5.4 x 105	1.62 x 104	1.41 x 105
Acetone	5.5 x 101d	NAd	5.5 x 101d
Benzene	1.4 x 101d	NAd	1.4 x 101d
Chloroform	9.5 x 102	3.31 x 101	1.06 x 102
Ethylbenzene	2.1 x 101	4.59 x 100	1.27 x 101
Methylene chloride	5.1 x 103	2.02 x 102	2.50 x 102
Tetrachloroethylene	6.3 x 103	4.30 x 102	9.08 x 102
Toluene	6.2 x 101	2.13 x 101	5.65 x 101
Trichloroethylene	5.1 x 105	1.38 x 105	1.90 x 105
Trichlorotrifluoroethane	1.3 x 103	2.37 x 101	3.60 x 102
Xylenes (total isomers)	4.0 x 101d	NAd	4.0 x 101d

a Estimate of the arithmetic mean of the underlying log-normal distribution.

b UCL = upper confidence limit.

c The chemical 1,2-dichloroethylene (1,2-DCE) exists as two isomers, cis-1,2-DCE and trans-1,2-DCE. At various times throughout the 9 years of ground water analysis at Site 300, this chemical has been analyzed for as 1,2-DCE (total), as one or both of the specific isomers, or as all three. When concentration data were available

for one or both isomers, we used those values and omitted the less specific analysis for 1,2-DCE (total) from
further consideration. The exceptions to this were in cases where the concentration reported for 1,2-DCE (total)
was greater than that reported for one or both isomers.

d This contaminant has only been detected a single time; consequently, neither a mean concentration nor a 95%
UCL were calculated. The concentration detected is given for the maximum concentration and the 95% UCL.
NA = not applicable.

e Analytical data originally presented in the SWRI report (data prior to December 31, 1991).

Table 2. Contaminants of potential concern in surface soil (0--0.5 ft) in the Building 834 operable unit.

Contaminant	Maximum concentration mg/kg (ppm)	Mean concentrationa	95% UCLb mg/kg (ppm)
Acetone	7.0 x 10-2	3.21 x 10-2	5.63 x 10-2
Cadmium	1.6 x 101	NAc	1.6 x 101c
Trichloroethylene	1.9 x 10-1	2.59 x 10-2	7.03 x 10-2
Trichlorofluoromethane	2.1 x 10-2	5.24 x 10-3	1.28 x 10-2
Trichlorotifluoroethane	9.5 x 10-2	1.49 x 10-2	3.66 x 10-2
Xylenes (total isomers)	5.0 x 10-3	2.86 x 10-3	3.55 x 10-3

a Estimate of the arithmetic mean of the underlying log-normal distribution.

b UCL = upper confidence limit.

c Because there was only a single sample and a single detection of this substance, a 95% UCL could not be
calculated. The value given is the only measured concentration. NA = parameter not applicable.

Table 3. Contaminants of potential concern in subsurface soil (>0.5--12.0 ft) at Building 834D.

	Maximum

Contaminant	Maximum concentration mg/kg (ppm)	Mean concentrationa	95% UCLb
Benzene	2.0 x 10-4c	NAc	2.00 x 10-4c
Ethylbenzene	1.3 x 10-3	2.55 x 10-4	6.16 x 10-4
Tetrachloroethylene	1.4 x 101	5.95 x 10-1	1.44 x 100
Toluene	1.2 x 10-3c	NAc	1.20 x 10-3c
Trichloroethylene	2.6 x 102	2.74 x 101	4.76 x 101
Trichlorofluoromethane	2.0 x 10-1	3.21 x 10-2	5.29 x 10-2
Xylenes (total isomers)	1.7 x 10-2	4.93 x 10-3	1.45 x 10-2

a Estimate of the arithmetic mean of the underlying log-normal distribution.

b UCL = upper confidence limit.

c No statistical calculations were made for this substance. The value given is the maximum measured concentration. NA = parameter not applicable.

Table 4. Compounds other than TCE reported in borehole soil and rock samples from the Building 834 operable unit.

Chemical	Maximum concentration detected in mg/kg (ppm)	No. of detections: Perched zone	Perching horizon	Neroly upper sandstone	Neroly aquitard	Neroly lower sandstone
Tetrachloroethylene (PCE)	14	30	11	0	0	0
1,1-Dichloroethylene (1,1-DCE)	0.0037	2	3	0	0	0

1,2-Dichloroethylene (1,2-DCE) (Total)	0.017	17	3	0	0
1,1,1-Trichloroethane (1,1,1-TCA)	0.0004	0	2	0	0
Trichlorofluoromethane (Freon 11)	0.2	4	1	0	1
Trichlorotrifluoroethane (Freon-113)	0.004	10	0	0	0
Dibromochloromethane	0.0004	1	0	0	0
Ethylbenzene	0.0035	13	1	0	0
Benzene	0.0013	11	3	0	0
Toluene	0.052	18	4	0	0
Xylene isomers	0.017	13	3	0	0
Total petroleum hydrocarbons	100	0	1	0	0
Chloroform	0.024	11	8	0	0
Carbon tetrachloride	0.0009	0	1	0	0
Methylene chloride	0.0028	3	0	0	1
HMX	0.0002	0	1	0	0
RDX	0.02	0	2	0	0

Table 5. Maximum concentrations of TCE encountered in soil vapor at the Building 834 operable unit.

Sample location	Depth (ft)	Maximum TCE concentration (ppmv/v)
SVS-834-B01	10.2	3,800 and 2,000a
SVS-834-B02	11.8	1,800 and 1,700a
SVS-834-C01	11.5	6,600 and 6,400a
SVS-834-D01	6.0	45 and 43a
SVS-834-D02	12.6	1,200 and 1,200a
SVS-834-D03	16.2	310 and 3109a
SVS-834-D04	16.4	1,300 and 1,000a
SVS-834-D05	15.5	270 and 160a
SVS-834-D06	15.0	510
SVS-834-D07	3.0	97
SVS-834-D08	20.0	6,300 and 6,500a
SVS-834-F01	9.4	16
SVS-834-G01	14.3	25
SVS-834-H01	14.7	7
SVS-834-H02	13.7	6,300
SVS-834-J01	10.0	4
SVS-834-J02	14.7	>700
SVS-834-M01	19.2	3.19

Notes:

a One of these concentrations is a duplicate sample result.

1. A general increase occurred in the concentration of TCE soil vapor with depth in each borehole (Webster-Scholten, 1994). In only 7 out of 22 sampling locations was there a deviation from this pattern. (Every sample was lower in concentration than those collected beneath it.)

2. In only 1 sampling location out of 22 was the maximum concentration at a depth of less than 5 ft. This occurred at location SVS-834-D07, about 18 ft to the northeast of pump station Building 834D. The concentration at a depth of 3 ft was 96.8 ppmv/v (v/v = on a volume-per-volume basis).

3. The overall maximum concentrations at a depth of less than 5 ft were as follows: 120 ppmvlv at 3.5-ft depth, SVS-834-C01, about 10 ft to the southeast of pump station Building 834C; 96.8 ppmv/v at 3-ft

depth, SVS-834-
D07; and 62.6 ppmv/v at 3-ft depth, SVS-834-B01, about 15 ft to the north of pump station Building 834B.

4. At 6 out of 22 sampling locations, the maximum concentrations were at depths of from 5.1 to 12 ft. These are:
SVS-834-B01, SVS-834-B02, SVS-C01, SVS-834-D01, and SVS-834-J01.

5. The overall maximum concentrations considering all depths were adjacent to pump station Buildings 834C and
D, and about 18 ft west of test cell 834H.

6. The second highest overall maxima at any depth were at pump station Buildings 834B, C, and D.

7. Although concentrations tend to increase with depth, the increases are not identical. Similar sample depths in
adjacent sample locations do not necessarily have similar concentrations. The lateral variability in the
magnitude of soil vapor concentrations is attributed to the variability in lithologic and moisture content of the
perched zone.

8. It is inferred that two mechanisms may be exerting control on the distribution of TCE in soil vapor at the core of
the Building 834 operable unit: (1) diffusion of TCE vapor from the upper surface of the TCE plume in ground
water; and (2) the "settling" of TCE in soil vapor onto a less permeable surface (in this case the
unsaturated/saturated soil interface), due to the density of TCE vapor relative to air.

Table 6. Summary of the fate and transport models applied to estimate human exposure-point concentrations in the Building 834 operable unit.

Media/process release area(s)	Chemicals of concern	Model and/or method at release area(s)	Maximum concentration	Potential exposure point(s)	Estimated exposure-point concentrations	95% UCL
Fugitive (airborne) dust; contaminants bound to resuspended soil particles						
Data evaluated are from surface soil samples collected throughout the study area.	Acetone	Mass-loading (Anspaugh et al., 1975).	0.07 mg/kga	Throughout the operable unit.	0.0563 mg/kga	1.29 x 10-9 mg/m3b
	Cadmium		16 mg/kga		16 mg/kga	3.68 x 10-7 mg/m3b
	TCE		0.19 mg/kga		0.0703 mg/kga	1.62 x 10-9 mg/m3b
	Freon 11		0.021 mg/kga		0.0128 mg/kga	

2.94 x 10-10 mg/m3b

Freon 113 0.095 mg/kga 0.0366 mg/kga
8.42 x 10-10 mg/m3b

Xylenes (total Isomers) 0.005 mg/kga 0.00359 mg/kga
8.17 x 10-11 mg/m3b

Direct contact with operable unit surface soil (<0.5 ft). Measured concentration of contaminant in surface soil. Throughout the (Exposure routes: incidental Ingestion and direct dermal contact)

Acetone 0.07 mg/kga 0.0563 mg/kga 5.63 x 10-2 mg/k8a

Cadmium 16 mg/kga 16 mg/kga 1.60 x 101 mg/kga

TCE 0.19 mg/kga 0.0703 mg/kga
7.03 x 10-2 mg/kga

Freon 11 0.021 mg/kga 0.0128 mg/kga
1.28 x 10-2 mg/kga

Freon 113 0.095 mg/kga 0.0366 mg/kga
3.66 x 10-2 mg/kga

Xylenes (total Isomer) 0.005 mg/kga 0.00355 mg/kga
3.55 x 10.3 mg/kga

Volutilization of contaminants from subsurface soil to air within a building and to the atmosphere

Area adjacent to pump station 834D. Volatilization from subsurface soil and diffusion into a building (McKone, 1992). Inside Building

Benzene 0.00020 mg/kgc 0.00020 mg/kgc 5.92 x 10-6 mg/m 3d

Building 834D. 3.46 x 10-6 mg/m 5e

Ethylbenzene 0.0013 mf/kgc 0.000616 ms/kgc
5.62 x 10-6 mg/m3d

5.38x 10-6 mg/m3e

Volutilization from the soil to the in the vicinity of Building 834D. atmosphere (Hwang et al., 1986).

PCE 14 mg/kgc 1.44 ms/kgc 3.64 x 10-2 mg/m3d

2.29 x 10-2 mg/m3e

Toluene 0.0012 mg/kgc 0.00120 mg/kgc
2.03 x 10-5 mg/m3d

1.49 x 10-5 mg/m3e

TCE 260 mg/kgc 47.6 mg/kgc
1.32 x 100 mg/kg3d

7.98 x 10-1 mg/m3e

Freon 11 0.20 mg/kgc 0.0529 mg/kgc

1.18 x 10-2 mg/m3d

5.47 x 10-33 mg/m3e

Xylenes (total Isomers) 0.017 ms/kgc 0.0145 mg/kgc
1.22 x 10.4 mg/m3d

1.21 x 10.4 mg/m3e

Table 6. (Continued)

Media/process release area(s)	Chemicals of concern	Maximum concentration at release area(s)	Model and/or method	Estimated exposure-point concentrations	Potential exposure point(s)
Soil/rock and ground water					
Core of the Building 834 Complex 300 area also considered. These include: 1,1-DCE, cis-1,2-DCE, 1,1,1-TCA, acetone, benzene, chloroform, ethulbenzene, methylene chloride, PCE, tolune, Freon 113, and xylenes (total Isomers).	Primarily TCE; co-contaminants detected in ground water samples in the study contributed from perched zone).	Perched zone; VLEACH 510,000 æg/L TCEf (U.S. EPA, 1981). Concentrations of co-	Assumed source term for VLEACll is 1,100 mg/L	95% UCL 1.6 x 10-4 æg/L TCF (maximum concentration (ppm) TCF Maximum 70-year average TCE concentration predicted in well CDF-1 from the perched zone is 1.5 x 10-4 ms/L	Well CDF-1, completed in the regional aquifer, 4,10 ft downgradient from the Building 834 and outside the Site boundary.

contaminants from the

perched zone in the

range of 10-9 to

10-4 mg/L.

Regional aquifer; PLUME 3.5 æg/Lf

(In-Situ, Inc., 1986).

Well CDF-1, completed in the regional aquifer, 4,100 ft gradient from the Building 834 CDF-1 from Complex and outside the Site boundary.

1,1,1-TCA, chloroform, methylene chloride, PCE, toluene, Freon 113, and TCE.

Assumed source term for PLUME is all detected VOC concentrations

Concentrations of VOCs predicted to arrive at 300 aquifer wells W-031-01, W-634-T1, and W-834-T3 from regional aquifer wells: range from 10-13 to 10-12 mg/L (ppb).

down-

W-834-T1, W-834-T3, and W-831-01

The expousre-point concentrations in ground water These were treated as instananeous point sources.

withdrawn from CDF-1.

a Surface soil (0-0.5 ft).
b Air.
c Subsudafe soil (0.5-12.0 ft).
d Indoor air.
e Outdoor air.
f Ground water.

Table 7. Calculation of excess individual lifetime cancer risk attributable to inhalation of VOCs that volalilize from subsurface soil (>0.5 to 12 ft) to air in the vicinity of Building 834D in the Building 834 operable unit (adult on-site exposure).

Dose(inh)	Slope factor for risk (R)	Ca(abs)	PEF(inh)	Source of information for

Chemical	[1/(mg/kg d)]	(mg/m-3)a slope factorc	(m3/(kg d)]b	[mg/(kg,d)]b	Excess individual 70-year lifetime cancer risk
Benzene	1.00E-01	3.46-06 State of Calif.	6.99E.02	2.42E-07	2.42E-08
Ethylbenzene	Not carcinogenic	5.38E-06 NAd	1.96E-01	1.05E-06	NAd
Tetrachloroethylene	5.10E-02	2.29E-02 State of Calif.	6.99E-02	1.60E-03	8.17E-05
Toluene	Not carcinogenic	1.49E-05 NAd	1.96E-01	2.92E-06	NAd
Trichloroethylene	1.00E-02	7.98E-01 State of Calif.	6.99E-02	5.58E-02	5.58E-04
Trichlorofluoromethane	Not carcinogenic	5.47E-03 NAd	1.96E-01	1.07E-03	NAd
Xylenes	Not carcinogenic	1.21E-04 NAd	1.96E-01	2.38E-05	NAd

äRisk = 6.40E-04

a Ca(sbs) refers to the concentration (C) of contaminant in air (a) (the exposure medium), which results directly from the presence of contaminant in subsurface soil (sbs).
b PEF = pathway exposure factor; inh = exposure and/or dose from inhalation.
c State of Calif. refers to California Environmental Protection Agency (1992).
d NA - parameter not applicable.

Table 8. Calculation of excess individual lifetime cancer risk attributable to inhalation of VOCs that volatilize from soil into the indoor air of Building 834D in the Building 834 operable unit (adult on-site exposure).

Chemical	(1/[mg/(kg d)]b	CVOC(sbs) (mg/m3)a slope factorc	PEF(inh) [m3/(kg d)]b	Dose(inh) [mg/(kg d)]b	Excess Individual 70-year lifetime cancer risk
Benzene	1.00E-01	5.92E-06 State of Calif.	6.99E-02	4.14E-07	4.14E-08
Ethylbenzene	Not carinogenic	5.62E-06 NAd	1.96E-01	1.10E-06	NAd
Tetrachloroethylene	5.10E-02	3.64E-02 State of Calif.	6.99E-02	2.55E-03	1.30E-04
Toluene	Not carcinogenic	2.03E-05 NAd	1.96E-01	3.98E-06	NAd
Trichloreothylene	1.00E-02	1.32E+00 State of Calif.	6.99E-02	9.23E-02	9.23E-04
Trichlorofluoromethane	Not carcinogenic	1.18E-02 NAd	1.96E-01	2.31E-03	NAd
Xylenes	Not carcinogenic	1.22E-04 NAd	1.96E-01	2.39E-05	NAd

a CVOC(sbs) refers to the concentration (C) of volatile organic compound in indoor air (VOC) (the exposure mediuml, which relults direoily irom ihe presence ot contaminanl in subsurface soil (sbs).
b PEF = pathway exposure factor, inh = exposure and/or dose from inhalation.
c State of Calif. refers to California Environmental Protection Agency (1992).
d NA = parameter not applicable.

Table 9. Calculation of excess individual lifetime cancer risk attributable to inhalation of particulates resuspended from contaminated surface soil (0 to 0.5 ft) in the Building 834 operable unit (adult on-site exposure).

Chemical	Dose(inh) [mg/(kg d)]b	Slope factor for risk (R) (1/[mg/(kg d)]b	Source of information for slope factorc	CVOC(sbs) (mg/m3)a	PEF(inh) [m3/(kg d)]b	Excess Individual 70-year lifetime cancer risk
Acetone	2.54E-10	Not carcinogenic	NAd	1.29E-09	1.96E-01	NAd
Cadmium	2.57E-08	1.50E+01	State of Calif.	3.68E-07	6.99E-02	3.86E-07
Trichloroethylene	1.13E-10	1.00E-02	State of Calif.	1.62E-09	6.99E-02	1.13E-12
Trichlorofluoromethane	5.76E-11	Not carcinogenic	NAd	2.94E-10	1.96E-01	NAd
Trichlorotrifluoroethane	1.65E-10	Not carcinogenic	NAd	8.42E-10	1.96E-01	NAd
Xylenes	1.60E-11	Not carcinogenic	NAd	8.17E-11	1.96E-01	NAd

äRisk = 3.86E-07

a Cp(ss) refers to the concentration (C) of contaminant on resuspended particulates in air (p) (the exposure medium), which results directly from the presence of contaminant in surface soil (ss).
b PEF = pathway exposure facror, inh = exposure and/or dose from inhalation.
c State of Calif. refers to California Environmental Protection Agency (1992).
d NA = parameter not applicable.

Table 10. Calculation of excess individual lifetime cancer risk attributable to incidental ingestion and direct dermal contact with contaminated aurtace soil (0 to 0.5 ft) in the Building 834 operable unit (adult on-site exposure).

Source of	Ingestion excess individual 70- Cs(ss)	Dermal excess Individual 70- PEF(ing)	Total excess Dose(ing)	Slope factor for Slope factor for risk (R)

Chemical	Cp(ss) (mg/kg)a	PEF(derm) [kg/(kg d)]b	Dose(derm) [mg/(kg d)]b	risk (R) (1/[mg/(kg d)])
Acetone	5.63E-02	4.89E-07	2.75E-08	Not carcinogenic
Cadmium	1.60E+01	1.74E-07	2.78E-06	Not available
Trichloroethylene	7.03E-02	1.74E-07	1.22E-08	1.50E-02
Trichlorofluoromethane	1.28E-02	4.89E-07	6.25E-09	Not carcinogenic
Trichlorotrifluoroethane	3.66E-02	4.89E-07	1.79E-08	Not carcinogenic
Xylenes	3.55E-03	4.89E-07	1.74E-09	Not carcinogenic

Chemical	individual 70-year lifetime cancer risk slope factorc	70-year lifetime cancer risk [kg/(kg d)]b slope factort	year lifetime [mg/(kg d)]b [(mg/(kg d)])	Source of information for risk (R)
Acetone	NAd	8.93E-07	3.34E-08	Not carcinogenic
Cadmium	Not available	Not available	7.06E-08	1.13E.O6
Trichloroethylene	1.84E-10	2.12E-07	1.49E-08	1.50E-02
Trichlorofluoromethane	NAd	5.93E-07	7.58E-09	Not carcinogenic
Trichlorotrifluoroethane	NAd	5.93E-07	2.17E-08	Not carcinosenic
Xylenes	NAd	5.93E-07	2.11E-09	Not carcinogenic

Chemical	Source of information for RfDc	Reference dose (RfD) [mg/(kg d)]	Hazard quotient (Dose/RfD)	Comments
Acetone	NAd	NAd	NAd	NAd
Cadmium	Not available	Not available	Not available	Not available
Trichloroethylene	State of Calif.	2.24E-10	4.07E-10	
Trichlorofluoromethane	NAd	NAd	NAd	NAd
Trichlorotrifluoroethane	NAd	NAd	NAd	NAd
Xylenes	NAd	NAd	NAd	NAd

ä Total risk = 4.07E-10

äRisk = 3.86E-07

a Cp(ss) refers to the concentration (C) of contaminant in surface soil(s) (the exposure medium), which results directly from the presence of contaminant in surface soil (ss).

b PEF = pathway exposure facror; "inh" = exposure and/or dose from ingestion; and "derm" = exposure and/or dose from dermal absorption.

c State of Calif. refers to California Environmental Protection Agency (1992).

d NA = parameter not applicable.

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Table 12. Calculation of noncancer hazard index attributable to inhalation of VOCs that volatilized from subsurface soil (>0.5 to 12 ft) in the vicinity of Building 834D in the building 834 operable unit (adult on site exposure).

Chemical	Ca(sbs) (mg/m3)a	PEF(ing) [m3/(kg d)]b	Dose(ing) [mg/(kg d)]	Chronic Reference dose (RfD) [mg/(kg d)]	Hazard quotient (Dose/RfD)	Source of information for RfDc	Comments
Benzene	3.46E-06	1.96E-01	6.78E-07	Not available	Not available	Not available	
Ethylbenzene	5.38E-06	1.96E-01	1.05E-06	1.00E-01			

1.05E-05	IRIS							
Tetrachloroethylene		2.29E-02	1.96E-01	4.49E-03		1.00E-02		
4.49E-01	IRIS							
Toluene		1.49E-05	1.96E-01	2.92E-06		2.00E-01		
1.46E-05	IRIS							
Trichloroethylene		7.98E-01	1.96E-01	1.56E-01		7.35E-03		
2.12E+01	State of Calif.							
Trichlorofluoromethane		5.47E-03	1.96E-01	1.07E-03		2.00E-01		
5.36E-03	HEAST		Based on RfD (inh)					
Xylenes		1.21E-04	1.96E-01	2.38E-05		2.00E+00		
1.19E-05	IRIS							

a Ca(sbs) refers to the concentration (C) of air (a) (the exposure medium), which results directly from the presence of contaminant in surface soil (sbs).
b Abbreviations are pathway exposure factor (PEF) and "inh" to indicate exposure and/or dose from inhalation.
c HEAST refers to the Health Effects Assessment Summary Tables published by the U.S. EPA (1992b,c); State of Calif. refers to California Environmental Protection Agency (1992); IRIS refers to the Integrated Risk Information System, an on-line database maintained by the U.S EPA (1992d).

Table 13. Calculation of noncancer hazard index attributable to inhalation of VOCs that volatilize from soil into the indoor air of Building 834D in the Building 834 operable unit (adult on-site exposure).

Chemical	Ca(sbs) (mg/m3)a	PEF(ing) [m3/(kg d)]b	Dose(ing) [mg/(kg d)]	Chronic Referemce dose (RfD) [mg/(kg d)]	Hazard quotient (Dose/RfD)	Source of information for RfDc	Comment
Benzene	5.92E-06	1.96E-01	1.16E-06	Not available	Not available	Not available	
Ethylbenzene	5.62E-06	1.96E-01	1.10E-06	1.00E-01	1.10E-05	IRIS	
Tetrachloroethylene	3.64E-02	1.96E-01	7.14E-03	1.00E-02	7.14E-01	IRIS	
Toluene	1.32E+00	1.96E-01	2.59E-01	7.35E-03	3.52E+01	IRIS	
Trichloroethylene	1.18E-02	1.96E-01	2.31E-03	2.00E-01	1.15E-02	State of Calif.	
Trichlorofluoromethane	2.03E-05	1.96E-01	2.98E-06	2.00E-01	1.99E-05	HEAST	Based on RfD (inh)
Xylenes	1.22E-04	1.96E-01	2.39E-05	2.00E+00	1.20E-05	IRIS	

Hazard Index = 3.59E+01

a CVOC(sbs) refers to the concentration (C) of volatile organic compound in indoor air (voc) (the exposure medium), which results directly from the presence of contaminant in subsurface soil (sbs).
b Abbreviations are pathway exposure factor (PEF) and "inh" to indicate exposure and/or dose from inhalation.
c HEAST refers to the Health Effecsts Assessment Summary Tables published by the U.S. EPA (1992b,c); State of Calif. refers to California Environmental Protection Agency (1992); IRIS refers to the Intergrated Risk Information System, an on-line database maintained by the U.S. EPA (1992d).

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Table 14. Calculation of noncancer hazard index attributable to inhalation of particulates resuspended from contaminated surface soil (0 to 0.5 ft) in the Building 834 operable unil (adult on-site exposure).

Chemical	Cp(ss) (mg/m3)a	PEF(ing) [m3/(kg d)]b	Dose(ing) [mg/(kg d)]	Chronic Referemce dose (RfD) [mg/(kg d)]	Hazard quotient (Dose/RfD)	Source of information for RfDc	Comment
Acetone	1.29E-09	1.96E-01	2.54E-10	1.00E-01	2.54E-09	IRIS	
Cadmium	3.68E-07	1.96E-01	7.21E-08	1.00E-03	7.21E-05	IRIS	
Trichloroethylene	1.62E-09	1.96E-01	3.17E-10	7.35E-03	4.31E-08	State of Calif.	
Trichlorofluoromethane	2.94E-10	1.96E-01	5.76E-11	2.00E.01	2.88E-10	HEAST	Based on RfD (inh)
Trichlorotrifluoroethane	8.42E-10	1.96E-01	1.65E-10	3.00E+01	5.50E-12	IRIS	
Xylenes	8.17E-11	1.96E-01	1.60E-11	2.00E+000	8.00E-12	IRIS	

Hazard index = 7.22E-05

a Cp(ss) referr to the concentration (C) of contaminant on resuspended particulates in air (p) (the exposure medium), which results directly from the presence of contaminant in surface soil (ss).
b PEF = pathway exposure fator; inh = exposure and/or dose from inhalation.
c HEAST refers to the Health Effects Assessment Summary Tables published by the U.S. EPA (1992b,c); State of Calif. refers to California Environmental Protection Agency (1992); IRIS refers to the Integrated Risk Information System, an on-line database maintained by the U.S. EPA (1992d).

Table 15. Calculation of noncancer hazard index attributable to incidental ingestion and direct dermal contact with surface soil (0 to 0.5 ft) in the Building 834 operable unit (adult on-site exposure).

Chemical	Cs(ss) (mg/m3)a	PEF(ing) [m3/(kg d)]b	Dose(ing) [mg/(kg d)]b	PEF(derm) [mg/(kg d)]d	Dose(derm) [mg/(kg d)]d	äDose [mg/(kg d)]	Chronic Reference dose (RfD) [mg/(kg d)]	Hazard quotient (Dose/RfD)	Source of information for RfDc
Acetone	5.63E-02	4.89E-07	2.75E-08	5.93E-07	3.34E-08	6.09E-08	1.00E+01	6.09E-07	IRIS
Cadmium	1.60E+01	4.89E-07	7.82E-06	1.98E-07	3.17E-06	1.10E-05	1.00E-03	1.10E-02	IRIS
Trichloroethylene	7.03E-02	4.89E-07	3.44E-08	5.93E-07	4.17E-08	7.61E-08	7.35E-03	1.04E-05	State of Cailf.
Trichlorofluoromethene	1.28E-02	4.89E-07	6.25E-09	5.93E-07	7.58E-09	1.38E-08	3.00E-01	4.61E-08	IRIS
Trichlomlrlfluoroethane	3.66E.02	4.89E-07	1.75E-08	5.53E.07	2.17E-08	3.96E-08	3.00E+01	1.32E-09	IRIS
Xylenee	3.55E-03	4.89E-07	1.74E-09	5.93E-07	2.11E-09	3.84E-09	2.00E+00	1.92E-09	IRIS

Hazard index = 1.10E-02

a Cs(ss) refers to the concentration (C) of contaminant in surface soil (s) the exposure medium), which results directly from the presence of contaminant in surface soil (ss).
b PEF = pathway expolure factor; "ing" - exposure and/or date from ingestion; and "derm" - exposure and/or dose from dermal absorption.
c State of Calif. refers to California Environmental Protection Agency (1992); IRIS refers to the Integrated Risk Information System, an on-line computerized database maintain by the U.S. EPA (1992d).

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Table 17. Estimated incremental lifetime cancer risk and noncancer hazard index associated with potential adult on-site exposure in the Building 834 operable unit (pump station Building 834D: inhalation of VOCs that volatilize from subsurface soil to indoor air).

Chemical	Contaminant concentration Cvoc(sbs) (mg/m3)a	Individual lifetime cancer risk	Hazard index (Dose/RfD)
Benzene	5.92 x 10-6	4.14 x 10-8	Not availableb
Ethylbenzene	5.62 x 10-6	Not carcinogenic	1.10 x 10-5
Tetrachloroethylene	3.64 x 10-2	1.30 x 10-4	7.14 x 10-1
Toluene	2.03 x 10-5	Not carcinogenic	3.52 x 101
Trichloroethylene	1.32 x 100	9.23 x 10-4	1.15 x 10-2
Trichlorofluoromethane	1.18 x 10-2	Not carcinogenic	1.99 x 10-5
Xylenes	1.22 x 10-4	Not carcinogenic	1.20 x 10-5
			ä
Hazard index = 36	ä Risk =	1 x 10-3	

a Cvoc(sbs) refers to the concentration (C) of volatile organic compound in indoor air (voc) (the exposure medium), resulting directly from the presence of contaminant in subsurface soil (sbs).

b A reference dose (Rfd) is not available.

Table 18. Estimated incremental lifetime cancer risk and noncancer hazard index associated with potential adult on-site exposure in the Building 834 operable unit (vicinity of pump station Building 834D: inhalation of VOCs that volatilize from subsurface soil to air).

Chemical	Contaminant concentration	Individual lifetime cancer risk	Hazard index

Chemical	Ca(sbs) (mg/m3)a	cancer risk	(Dose/RfD)
Benzene	3.46 x 10-6	2.42 x 10-8	
Ethylbenzene	5.38 x 10-6	Not carcinogenic	Not availableb
Tetrachloroethylene	2.29 x 10-2	8.17 x 10-5	1.05 x 10-5
Toluene	1.49 x 10-5	Not carcinogenic	4.49 x 10-1
Trichloroethylene	7.98 x 10-1	5.58 x 10-4	1.46 x 10-5
Trichlorofluoromethane	5.47 x 10-3	Not carcinogenic	2.13 x 101
Xylenes	1.21 x 10-4	Not carcinogenic	5.36 x 10-3
ä Risk =		6 x 10-4	1.19 x 10-5

ä Hazard index = 22

a Ca(sbs) refers to the concentration (C) of contaminant in air (a) (the exposure medium), resulting directly from the presence of contaminant in subsurface soil (sbs).

b A reference dose (Rfd) is not available.

Table 19. Estimated incremental lifetime cancer risk and noncancer hazard index associated with potential adult on-site exposure in the Building 834 operable unit (overall operable unit: inhalation of particulates resuspended from surface soil).

Chemical	Contaminant concentration Cp(ss) (mg/m3)a	Individual lifetime cancer risk	Hazard index (Dose/RfD)
Acetone	1.29 x 10-9	Not carcinogenic	2.54 x 10-9
Cadmium	3.68 x 10-7	3.86 x 10-7	7.21 x 10-5
Trichloroethylene	1.62 x 10-9	1.13 x 10-12	4.31 x 10-8
Trichlorofluoromethane	2.94 x 10-10	Not carcinogenic	2.88 x 10-10
Trichlorotrifluoroethane	8.42 x 10-10	Not carcinogenic	5.50 x 10-12
Xylenes	8.17 x 10-11	Not carcinogenic	8.00 x 10-12
ä Risk =		4 x 10-7	ä Hazard index = 7.2 x 10-5

a Cp(ss) refers to the concentration (C) of contaminant on resuspended particulates in air (p) (the exposure
medium), resulting directly from the presence of contaminant in surface soil (ss).

Table 20. Estimated incremental lifetime cancer risk and noncancer hazard index associated with potential adult on-site exposure in the Building 834 operable unit (overall operable unit: ingestion and dermal adsorption from surface soil).

Chemical	Contaminant concentration Cs(ss) (mg/kg)a	Individual lifetime cancer risk	Hazard index (Dose/RfD)
Acetone	5.63 x 10-2	Not carcinogenic	6.09 x 10-7
Cadmium	1.60 x 101	Not availableb	1.10 x 10-2
Trichloroethylene	7.03 x 10-2	4.07 x 10-10	1.04 x 10-5
Trichlorofluoromethane	1.28 x 10-2	Not carcinogenic	4.61 x 10-8
Trichlorotrifluoroethane	3.66 x 10-2	Not carcinogenic	1.32 x 10-9
Xylenes	3.55 x 10-3	Not carcinogenic	1.92 x 10-9
		ä	Hazard
	ä Risk =	4 x 10-10	index = 1.1 x 10-2

a Cs(ss) refers to the concentration (C) of contaminant in surface soil (S) (the exposure medium), resulting
directly from the presence of contaminant in surface soil (ss).

b A slope factor for ingestion or dermal exposure to cadmium is not available.

Table 21. Additive risk and hazard index for adults on site in the Building 834 operable unit (total outdoor exposure only).

Region or source of exposure	Calculated risk associated with the region or source	Calculated hazard index associated with the region or source
Subsurface soil in the vicinity of Building 834D	6 x 10-4	22
Surface soil throughout the	4 x 10-7	

7.2 x 10-5
study area (resuspended
particulates)

Surface soil throughout the 4 x 10-10
1.1 x 10-2
study area (ingestion and
dermal contact)

ä Risk = 6 x 10-4 ä Hazard index
= 22

Note:

Exposure within the Building 834D is not included in this summation. Indoor air exposure is considered as a
separate scenario and presented in Table 17.

Table 22. Estimated incremental lifetime cancer risk and noncancer hazard index associated with potential residential exposures to contaminated ground water that originates in the Building 834 operable unit (well CDF-1).

	Contaminant concentration	Individual lifetime	Hazard index
	Cw(gw) (mg/L)a	cancer risk	(Dose/RfD)
1,1,1-Trichloroethane	1.32 x 10-8	Not carcinogenic	7.24 x 10-9
1,1-Dichloroethylene	6.00 x 10-11	2.77 x 10-12	6.89 x 10-10
Acetone	3.90 x 10-11	Not carcinogenic	2.85 x 10-11
Benzene	9.90 x 10-12	4.37 x 10-14	Not availableb
Chloroform	7.48 x 10-11	2.00 x 10-13	7.00 x 10-10
cis-1,2-Dichloroethylene	9.99 x 10-8	Not carcinogenic	1.01 x 10-6
Ethylbenzene	8.98 x 10-12	Not carcinogenic	9.45 x 10-12
Methylene chloride	1.77 x 10-10	5.21 x 10-14	3.10 x 10-10
Tetrachloroethylene	6.44 x 10-10	1.49 x 10-12	6.60 x 10-9
Toluene	4.01 x 10-11	Not carcinogenic	1.98 x 10-11
Trichloroethylene	1.35 x 10-7	6.38 x 10-11	1.67 x 10-6
Trichlorotrifluoroethane	2.55 x 10-10	Not carcinogenic	8.44 x 10-13
Xylenes	2.84 x 10-11	Not carcinogenic	1.53 x 10-12

ä Hazard

		ä Risk =		7 x 10-11
index =	2.8 x 10-6			

a Cw(gw) refers to the concentration (C) of contaminant in water (w). Water is the exposure medium for ingestion and dermal absorption of contaminants, and also is the transfer medium for exposures that result from ingestion of homegrown beef, milk, and fruits and vegetables that are raised with contaminated ground water (gw).

b A reference dose (RfD) is not available.

Table 23. Concentration of TCE in subsurface soil, Cs, associated with a hazard index of 1, cancer risks of 10-4 and 10-6, and U.S. EPA Region IX PRG.

	Hazard index	Excess cancer risk	Excess cancer risk	Region IX PRG	Region IX PRG
	(1)	(10-4)	(10-6)	industrial soil	residential soil
Cs (mg/kg)a	2.2b	7.45	7.45 x 10-2	7.3	3.3

a Cs (mg/kg) is the calculated concentration of TCE in soil associated with a specific target hazard or risk and represents a potential soil remediation level.

b The soil vapor concentration at equilibrium with 2.2 mg/kg is 250 ppmv/v.

Table 24. Detailed evaluation of remedial alternatives for the Building 834 operable unit.

	Evaluation criteria					
Remedial alternative	Overall protection of human heatlh and the environment	Compliance with ARARs/RAO	Reduction in volume, toxicity, and mobility	Long-term effectiveness and pemnanence	Short-term efiectivenees	Implementability
Alternative 1 No action	Is not protective of human health and the environment or the human inhalation toxicity of VOCs not would be reduced.	Does not meet ARARs or the human inhalation ISVRLs.	Does not reduce VOCs in soil vapor to Volume, mobility, and	No impact to general public. Possible exposure of workers Ongoing monitoring at the Building 834	Implementable.	

reduced. Subsurface during drilling and monitoring.
Complex.
restoration depends on Use of protective procedures,

natural degration clothing, and equipment will
Maintains acceptable risk
dispension, and mitigate risk.
associated with off-site
evapotranspiration of
downgradient water-supply
VOCs.
wells completed in the
regional aquifer.

Alternative 2 Exposures to human health Meets all ARARs, and
Localized infiltration and drainage LNAPLs removed from No impact to
general public. Implementable.
inhalation exposure risks reduced to EPA- achieves the human
control will prevent migration of site.
controls, LNAFL accepted levels
inside inhalation RAO.
VOCs from source areas.
Short-term impact to workers and
Building ventilation would maintain air
recovery; and drainage buildings but not
outside.
Volume and toxicity of access to Building
834 facilities concentrations at
acceptable levels. Hardware
controls
Building ventilation and institutional
VOCs in soil and during drilling
and construction. is readily
available.
No air emissions.
controls will reduce inhalation health ground water not Coordinate
short-term shutdown of

risks to workers to Building 834
reduce. Infiltration Building 834
facilities. Standard
design and contruction techniques
Maintains
acceptable risk
Complex building to EPA-accepted
control will reduce
and materials used for drainage control.
associated with off-site
levels. Does not reduce VOCs in soil mobility. Possible
exposure of workers
downgradient
water-supply
vapor to SVRLs.
during monitoring LNAPL
Passive skimmers readily available
wells completed in
the
Source mass reduction recovery, and
surface grading. Use Recorded LNAPLs
will be managed as a
regional aquifers.

depends on natural of protective procedures, clothing, hazardous waste.

degradation, dispersion, and equipment will mitigate risk.

and evapotranspiration Cost provided for LNAPL recovery Low maintenance, long-term effecriveness,

and VOCs. for 2-years duration. low costs.

Alternative 3 Exposure to human health Meets all ARARs, and Removes VOCs. SVE and treatment Volume and toxicity of No impact to general public. Implementable. SVE and air emissions Source mass removal risks reduced to EPA- achieves the human system operated until soil vapor VOCs reduced by control using GAC are BAT for removing by SVE and LNAPL accepted levels. inhalation RAO. concentrations indicate that SVRLs LNAPL recovery, SVE GAC used to control air emissions VOCs from vadose zone. recovery, exposure have been achieved or effectiveness of and treatment. VOC from SVE, preventing impact on and drainage controls Adverse impacts to the technology is expired (estimated vapor migration community. Subsurface hydrogeology is appropriate for environment from VOCs are 5 year). controlled by SVE. SVE. substantially reduced. Provides option to conduct pilot

Mass removal reduces potential for Off-site thermal tests and implement promising LLNL has permits for contruction and Results in negligible risk to VOC migration to regional aquifer, regeneration of spent innovative technologies using BAT operation SVE treatment system. employees and the public GAC destroys VOCs. to ensure that no releases occur. from system operation or Spent GAC is generated off site. Servicec and materials for system exposure to air emissions. VOC solubilities and Possible exposure

of workers construction, O&M,
and off-site generation

LNAPLs are recycled or disposed of
diffusion rates limit during monitoring,
LNAPL of GAC are
available.
Maintains acceptable
off site. total mass removal of recovery,
drilling, and contruction
exposure risk
associated
VOCs dissolved in of piping and
treatment systems. Substantial
portion of the system is in place
with off-site downgradient
Localized infiltration and drainage grounds water or from Use of
protective procedures, and operating.
water supply well
control will prevent migration of probable DNAPLs. clothing, and
equipment will
completed in the
regional
VOCs from source areas.
mitigate risk.
Building LNAPLs is a standard technology.
aquifer.
Natural degradation
concentrations at acceptable levels. Hardware

Building centilation and institutional
and evapotranspiration Remediation costed
for 5-year is readily
available.

controls will reduce inhalation health of VOCs continues. duration.

risks to workers in Building 834 core
Standard design and contruction techniques

area buildings.
and materials used for drainage control.

Table 24. (Continued)

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Evaluation criteria

Overall protection of human Compliance with
Long-term effectiveness and Reduction to volume,
Remedial alternative health and the
environment ARARs/RAO

permanence toxicity,
and mobility Short-term
effectiveness
Implemenlability

Alernative 3ÄContinued
Current industrial health, safely, and Possible reduction in

hygiene and hazardous materials volume, toxicity, and

handling practices are designed to
mobility due to

prevent creation of new sources. bioremediation

augmented by SVE.

Provides option to conduct pilot tests

and implement promising inovative

technologies.

Soil vapor and gound water

monitoring continue after remedialton

to ensure permanence of shallow

vadose-zone cleanup.

Alternative 4 Exposures to
human health Meets all ARARs, and
Removes VOCs. Soil vapor extraction
Volume and toxicity of No impact to
general public. Implementable,
SVE and air emissions
Source mass removal by risks reduced
to EPA- achieves the human
and treatment system operaled until
VOCs reduced by SVE,
cantrol using GAC are BAT for removing
SVE with dewatering accepted
levels. inhalation RAO.
soil vapor concentraUons indicate that
dewatering, and GAC used to
control air emission VOCs from
vadose zone.
and by DNAPL and
SVLRs have been achieved or treatment. from air
stripper and SVE,
LNAPL recovery, Adverse
impacts to
effectiveness of technology is expired
preventing impact on community.
Subsurface hydrogeology is appropriate for
exposure and drainage substantially reduced.
(estimated 5 years). VOC vapor migration

SVE.
 controls
controlled by SVE. Provides capability to conduct pilot
  Results in
negligible risk to
Dewatering increases SVE
tests and implement promising
Dewatering in the core area will expose more
  employees and
the public
effectiveness and mass removal.
VOC mobility at Innovative
technologies using BAT soil and
enhance mass removal by SVE.
  from system operation or
complex reduces by to ensure that no release occur.
  exposure to
discharged
Mass removal reduces potential for
hydraulic control
LLNL has permits for contruction and
  treated water
of all
VOC migration to regional aquifer.
during dewatering. Possible
exposure of workers operation
of SVE treatment system
  emissions.
during monitoring LNAPL

Spent GAC is regenerated off-site.
VOC solubilities and recovering,
drilling and construction Air stripping
is BAT for removing VOCs in
  Maintains
acceptable
diffusion rates limit of piping and
treatment systems. ground water.
Tray aeration eliminates
  exposure risk
associated
DNAPLs and LNAPLs are recycled or
total mass removal of Use of
protective procedures, adverse
visual impact of packed towers.
  with off-site
downgradient
disposed of off-site.
VOCs dissolved in clothing, and
equipment will Recarbonation
system reduces O&M due to
  water-supply
wells
ground water or from mitigate risk.
carbonate precipitation.
  completed in the regional
Localized infiltration and drainage probable DNAPs.
  aquifer.
control will prevent migration to
Services and materials for system

VOCs from source areas.
Off-site thermal
construction, O&M, and off-site regeneration

regeneration of spent
of GAC are available.

Building ventilation and institutional GAC destroys VOCs.

controls will reduce inhalation health
Substantial portion of the system is in place

risks to workers in Building 834 core Natural degradation
and operating.

area buildings. and evapotranspiration

of VOCs continues.
Standard requirements for treated ground

Current industrial health, safety and
water discharge would be met.

hygiene and hazardous materials Possible reduction in

handling practices are designed to
volume, toxicity, and
Recovered DNAPLs and LNAPLs will be

prevent creation of new sources.
mobility due to
managed as a hazardous waste.

bioremediation

Provides option to conduct pilot tests
augmented by SVE.
Building ventilaion would maintain air

and implement promising innovative
Infiltration control will
concentrations at acceptable levels. Hardware

technologies.
reduce mobility.
is readily available.

Soil vapor and grounding water
Standard design and construction techniques

monitoring continue after remediation
and materials used for drainage control.

to ensure permanence of shallow

vadose-zone cleanup.

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Table 24. (Continued)

Evaluation criteria

Evaluation criteria

Remedial alternative	Overall protection of human health and the environment	Compliance with ARARs/RAO	Long-term effectiveness and permanence	Reduction to volume, toxicity, and mobility	Short-term effectiveness	Implemenlability
Alternative 5	Exposures to human health and the environment during SVE and air emissions will be reduced by control using GAC are proven technologies for removing VOCs from vadose zone and controlling air emissions. Adverse impacts to community during dewatering and from air emissions will be minimized by control downgradient by ground water extraction, exposure and drainage controls	Meets all ARARs, and achieve the human health and ecological RAOs.	No impact to Implementable. risk reduces to EPA-contruction. accepted inhalation RAO.	Volume and toxicity of VOCs reduced by source mass removal by SVE with dewatering until soil vapor concentrations indicate that SDLs may be achieved. Soil LNAPL recovery, SVE and by DNAPL and confirmation sampling would be conducted to demonstrate that SRLs have been achieved and system would be shut off. Use of GAC to control emissions. LNALP recovery, plume stripper and SVE will treatment, and downgradient ground water extraction. Dewatering in the core area will expose more soil and enhace mass removal by SVE. Provides capability to conduct pilot tests and implement promising Dewatering increases SVE effectiveness and mass removal. Results in negligible risk to Subsurface hydrogeology is appropriate employees and the public VOC	Meets all ARARs, and SVE and treatment system operated until soil vapor concentrations indicate that SDLs may be achieved. Soil LNAPL recovery, SVE and by DNAPL and confirmation sampling would be conducted to demonstrate that SRLs have been achieved and system would be shut off. Use of GAC to control emissions. LNALP recovery, plume stripper and SVE will treatment, and downgradient ground water extraction. Dewatering in the core area will expose more soil and enhace mass removal by SVE. Provides capability to conduct pilot tests and implement promising Dewatering increases SVE effectiveness and mass removal.	Reduction to volume, toxicity, and mobility	Short-term effectiveness	Implementable.

vapor migration innovative
technologies using BAT for SVE.
from system operation or
controlled by SVE. to ensure that no releases occur.
exposure to
discharge
Downgradient ground water extraction
LLNL has permits for construction and
treated water
or air
and treatment operated until TCE VOC
mobility reduced Possible exposure of
workers operation of SVE
treatment system.
emissions.
concentrations reach asymptotic levels by hydraulic control. during
monitoring LNAPL

or MCLs whichever is higher
recovery, drilling, and construction
Substantial portion of treatmnet facility is
Maintains
acceptable
(estimated 30 years). VOC
solubilities and of pipping and
treatment system. constructed and
operating.
exposure risk associated
diffusion rates limit Use of protective procedures,
with off-site
downgradient
Mass removal reduces potential for
total mass removal of clothing, and
equipment will Operating and
discharge permits will be
water-suuply
wells
VOC migration to regional aquifer.
VOCs dissolved in mitigate risk.
obtained for treatment facility.
completed in the regional
ground water or
aquifer.
Spent GAC is regenerated off site.
probable DNAPLs. SVE costed for
5-year duration. Air stripping is
proven for treatment of VOCs

Ground water
extraction costed for in ground water.
Tray aeration eliminates

DNAPLs and LNAPLs are recycled or
Off-site thermal 5-, 10-, 20-, and
30-year durations. adverse visual impact
of packed towers.

disposed off site.
regeneration of spent
Recarbonation system reduces O&M due to

GAC destroys VOCs. carbonate precipitaion.

Localized infiltration and drainage

controls will prevent migration of
Natural degradation
Services and materials for system

contaminants of concern from source and
evapotranspiration
contruction, O&M, and for off-site

areas. of
VOCs continues.
regeneration of GAC are readily available.

Building ventilation and institutional
Possible reduction in
Recovered DNAPLs and LNAPLs will be

controls will reduce inhalation health
volume, toxicity, and
managed as a hazardous waste.

risks to workers in Building 834 core mobility due to

are buildings.
bioremediation
Building ventilation would maintain air

augmented by SVE.
concentrations at acceptable levelss. Hardware

Current industrial health, safety, and Infiltation control may
is readily available.

hygiene and hazardous materials eventually reduce

handling practices are designed to
volume.
Standard design and construction techniques

prevent creation of new sources.
and materials used for drainage control.

Provides option to conduct pilot tests

and implement promising innovative

technologies.

Soil vapor and ground water

monitoring continue after remediation

to ensure permanence of shallow

vadose-zone cleanup.

Table 24. (continued)

Evaluation criteria

Remedial alternative	Overall protection of human health and the environment	Compliance with ARARs/RAO	Long-term effectiveness and permanence	Reduction to volume, toxicity, and mobility	Short-term effectiveness	Implemenlability
Alternative 6a Remediation using Innovative technology						

a Innovative technology coupled with soil vapor extraction (enhanced by ground water extraction as needed) will address all evaluation criterial similartly to Alternative 3 or 4 if perched zone is excluded from Basin Plan.

Innovative technology coupled with soil vapor extraction (and contingent Alternative 5 BAT) will address all evaluation criteria similarly to Alternative 3 or 4 if perched zone is not excluded from Basin Area.

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Table 25. Comparative evaluation of remedial alternatives for the Building 834 operable unit.

Alternative	Overall protection of human health and environment	Compliance with ARARs/RAO	Long-term effectiveness and permanence	Reduction in volume, toxicity, and mobility	Short-term effectiveness	State Implementability	Community acceptance
Alternative 1	Human health: No Dependent on natural degradation	No Not effective	Not effective	Low	TBD	TBD	TBD
	Environment: No						
Alternative 2	Human health: Yes Limited reduction in core area	Yes Effective	Effective	Moderate	TBD	TBD	TBD
LNAPL contamiantion	Inside: Yes						

	Outside:	No				
	Environment:	No				
Alternative 3	Human health:	Yes	Yes			
Effective	Reduction in core area vadose zone		Effective			
Implementable	High	TBD	TBD			
and LNAPL contamination						
	Environment:	Yes				
Alternative 4	Human health:	Yes	Yes			
Effective	Reduction in froze azea vadose zone,		Very effective			
Implementable	High	TBD	TBD			
perched zone, and LNAPL contamination						
	Environment:	Yes				
Alternative 5	Human health:	Yes	Yes	Very effective		
Implementable	Reduction in core area vadose zone,		Very effective			
Very high a	TBD	TBD				
perched zone, and LNAPL contamination and downgradient perched zone contamination	Environment:	Yes				
Alternative 6						
If Perched zone	Same as Alternative 3 or 4	TBD	Same as Allentative 3 or 4			
excluded from Basin Plan						
If perched zone	Same as Alternative 5	TBD	Same as Alternative 5			
not excluded from Basin Plan						

TBD = To be determined.
a Overall cost is highly dependent on the required length of pumping time.

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Table 26. Soil vapor and ground water monitoring program for the Building 834 operable unit.

Alternative	1		2		3		4		5	
Phase	Soil vapor	Ground water	Soil vapor	Gound water	Soil vapor	Ground water	Soil vapor	Ground water	Soil vapor	Ground water

Monitoring period (years)	1-5	6-30	1-5	6-30	1-5	6-30	1-5	6-30	1	2-5	6-10	11-30	1	2-5	6-30	1	2-5	6-10	11-30	1-5	6-30	1	2-5	6-10	11-30	1-5	6-30	Comments
Well ID																												
W-834-B2	--	--	A	A	--	--	A	A	Q	B	A	--	A	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-B3	--	--	A	A	--	--	A	A	Q	B	A	--	A	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-B4 (new)	NA	NA	NA	NA	NA	NA	NA	NA	Q	B	A	--	A	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-C2	--	--	A	A	--	--	A	A	Q	B	A	--	A	Q	B	A	--	A	B	A	--	Q	B	A	--	A	B	GWE, SVE
W-834-C3 (new)	NA	NA	NA	NA	NA	NA	NA	NA	Q	B	A	--	A	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D2	--	--	A	A	--	--	A	A	--	--	--	--	A	Q	A	--	--	--	--	--	--	Q	A	--	--	Q	A	Guard well*
W-834-D3	--	--	B	A	--	--	Q	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D4	--	--	B	A	--	--	Q	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D5	--	--	B	A	--	--	Q	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D6	--	--	B	A	--	--	B	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D7	--	--	A	A	--	--	A	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D8	--	--	A	A	--	--	Q	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D9A	--	--	Q	A	--	--	Q	A	--	--	--	--	Q	Q	A	--	--	--	--	--	--	Q	A	--	--	Q	Q	Guard well
W-834-D10	--	--	A	A	--	--	A	A	Q	B	A	--	A	A	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D11	--	--	A	A	--	--	A	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D12	--	--	A	A	--	--	A	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D13	--	--	A	A	--	--	A	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-D14	--	--	A	A	--	--	A	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-G3	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	--	--	A	A	--	--	A	A	
W-834-H2	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	--	--	A	A	--	--	A	A	
W-834-J1	--	--	A	A	--	--	A	A	Q	B	A	--	A	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-J2	--	--	A	A	--	--	A	A	Q	B	A	--	Q	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-J3 (new)	NA	NA	NA	NA	NA	NA	NA	NA	Q	B	A	--	A	Q	B	A	--	Q	B	A	--	Q	B	A	--	Q	B	GWE, SVE
W-834-K1	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	--	--	A	A	--	--	A	A	
W-834-M1	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	--	--	A	A	--	--	A	A	
W-834-M2	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	--	--	A	A	--	--	A	A	
W-834-S1	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	--	--	A	A	--	--	A	A	
W-834-S2	--	--	A	A	--	--	A	A	--	--	--	--	A	Q	B	GWE	--	--	--	--	--	A	A	--	--	A	A	

W-834-S2A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	To be destroyed
W-834-S3	--	--	A	A	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	To be destroyed
W-834-S4	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	A	A	
W-834-S5	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	A	A	
W-834-S6	--	--	Q	A	--	--	Q	A	--	--	--	--	Q	Q	A	--	--	--	--	Q	A	--	--	--	--	Q	A	
W-834-S7	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	A	A	

Table 26. (Continued)

Alternative	1				2				3							4						5						
Phase	Soil vapor		Ground water		Soil vapor		Gound water		Soil vapor				Ground water			Soil vapor				Ground water		Soil vapor				Ground water		
Monitoring period (years) Well ID	1-5	6-30	1-5	6-30	1-5	6-30	1-5	6-30	1	2-5	6-10	11-30	1	2-5	6-30	1	2-5	6-10	11-30	1-5	6-30	1	2-5	6-10	11-30	1-5	6-30	Comments
W-834-S8	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	A	A	
W-834-S9	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	Q	B	
W-834-S10(new)	--	--	NA	NA	--	--	B	A	--	--	--	--	B	B	A	--	--	--	--	B	A	--	--	--	--	Q	A	
W-834-S11(new)	--	--	NA	NA	--	--	B	A	--	--	--	--	B	B	A	--	--	--	--	B	A	--	--	--	--	Q	B	CWE
W-834-S12(new)	--	--	NA	NA	--	--	B	A	--	--	--	--	B	B	A	--	--	--	--	B	A	--	--	--	--	Q	B	
W-834-T1	--	--	Q	A	--	--	Q	A	--	--	--	--	Q	Q	A	--	--	--	--	Q	A	--	--	--	--	Q	B	Guard well
W-834-T2	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	Q	B	CWE
W-834-T2A	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	Q	B	CWE
W-834-T2B	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	Q	B	
W-834-T2C	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	Q	B	
W-834-T2D	--	--	A	A	--	--	A	A	--	--	--	--	A	A	A	--	--	--	--	A	A	--	--	--	--	Q	B	CWE
W-834-T3	--	--	Q	A	--	--	Q	A	--	--	--	--	Q	Q	A	--	--	--	--	Q	A	--	--	--	--	Q	B	Guard well
W-834-T4	--	--	B	A	--	--	B	A	--	--	--	--	B	B	A	--	--	--	--	B	A	--	--	--	--	Q	B	CWE
W-834-T4A	--	--	B	A	--	--	B	A	--	--	--	--	B	B	A													

```
--  --  --   --     B     A   --  --   --   --   Q    B
  W-834-T4B      --   --      B    A     --    --     B     A    --  --   --   --    B    B   A
--  --  --   --     B     A   --  --   --   --   Q    B
  W-834-T4C      --   --      B    A     --    --     B     A    --  --   --   --    B    B   A
--  --  --   --     B     A   --  --   --   --   Q    B          CWE
   W-834-T5      --   --      Q    A     --    --     Q     A    --  --   --   --    Q    Q   A
--  --  --   --     Q     A   --  --   --   --   Q    B        Guard well
  W-834-T7A      --   --      Q    A     --    --     Q     A    --  --   --   --    Q    Q   A
--  --  --   --     Q     A   --  --   --   --   Q    B        Guard well
   W-834-T8      --   --      Q    A     --    --     Q     A    --  --   --   --    Q    Q   A
--  --  --   --     Q     A   --  --   --   --   Q    B        Guard well
   W-834-T9      --   --      Q    A     --    --     Q     A    --  --   --   --    Q    Q   A
--  --  --   --     Q     A   --  --   --   --   Q    B        Guard well
10 new shallow
soil vapor point B    A      NA   NA     B     A     NA    NA    Q   B    A     A    NA   NA  NA
Q    B   A   A     NA    NA    Q   B   A    A   NA   NA

Total samples
  Quarterly                 8Q                       12Q       29Q                 28A  8Q
29Q               28Q       29Q               40Q
Biannually     10B          11B          10B          8B            29B              7B  26B
29B            7B             29B               36B
  Annually            10A    30A  49A          10A    29A  49A            29A    10A  17A  18A
52A           29A  10A  17A   52A           29A  10A 12A  14A
```

Legend: Q = quarterly, B = biannually, A = annually, -- = no sampling, GWE = ground water extraction, SVE = soil vapor extraction, NA = not applicable,   = well is historically dry.
Note: Wells W-834-C2 and W-834-D10 will be used for GWE if water table rises.

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Table 27. Alternative 6: Capital costs for source mass removal at the core of the Building 834 operable unit using soil vapor extraction enhanced by dewatering.

	Quantity	Unit type	Unit price (1994 $)	Total (1994 $)
Capital costs				
Total fluids and soil vapor extraction (SIZE) system major equipment costs (MEC)				
Wellhead modifications	9 previously installed			
Additional wellhead modifications	10	each	500	5,000
Electrical supply line	Previously installed			
4-in. PVC piping	700	foot	8.20	5,740
2-1/2-in. PVC piping	700	foot	4.40	3,080
Nalgene tubing	1,000	foot	1.41	

1,410			
Pneumatic total fluids pumps	3 previously purchased		
Pneumatic total fluids pumps	16	each	2,400
38,400			
Pneumatic lines in wells	16	each	250
4,000			
Air compressors (7.5 hp)	1	each	5,000
5,000			
Air compressor lines in trenches	1,000	foot	1.40
1,400			
PVC pipe fittings, unistrut	1	lot	5,000
5,000			
Ground water extraction system valves, sampling ports, gauges	3 previously purchased		
Additional GWE valves, sampling ports, gauges	16	well	500
8,000			
SVE pitot tubes, vacuum gauges, sampling ports	9 previously installed		
SVE pitot tubes, vacuum gauges, sampling ports	10	well	1,000
10,000			
Ground water treatment MEC			
Phase separator (with LNAPL and DNAPL collection drums)	1	each	15,000
15,000			
Transfer drum (55 gallons)	3	each	200
600			
Air misting storage tank (5,000 gallons)	1	each	5,000
5,000			
Transfer pump (1/6 hp)	2	each	300
600			
Transfer pump (1-1/2 hp)	2	each	500
1,000			
Particulate filter assembly	Previously installed		
Low profile tray air stripper, Model 1321	1	each	13,000
1.3,000			
Knockout drum, demister, carbon bed hookup	1	each	1,100
1,100			
Air heater (700 W)	1	each	500
500			
Aqueous-phase carbon beds (200 lb)	2	each	500
1,000			
Vapor-phase carbon beds (1,000 lb)	2	each	6,000
12,000			

Table 27. Alternative 6: Capital costs for source mass removal at the core of the Building 834 operable unit using soil vapor extraction enhanced by dewatering.

Unit price type	Total (1994 $)	(1994 $)	Quantity	Unit
Air stripper vapor exhaust blower (2 hp)			1	each
3,500	3,500			
Manifold, piping, valves, gauges, sampling ports, totalizer, controllers			1	lot

10,000	10,000				
Discharge piping and fittings				Previously installed	
Pipe heating tape				2,000	foot
2	4,000				
Addition to existing air misting discharge unit				1	each
10,000	10,000				
SVE treatment MEC					
Knockout drum, demister, carbon bed hookup				1	each
1,100	1,100				
SVE blower system (10 hp)				Previously installed	
Air heater (700 W)				1	each
500	500				
Vapor-phase carbon beds (2,000 lb)				3	each
7,700	23,100				
Valves, gauges, sampling ports, controllers				1	lot
10,000	10,000				
SVE manifold, piping, exhaust				1	lot
10,000	10,000				
Total MEC for exposure control and ground water and SVE treatment systems					
209,030					
Electrical components (20% of MEC)					
41,806					
Installation cost (58% of MEC)					
121,237					
Major equipment installed cost (MEIC)					
372,073					
Drainage control					
Grading, asphalt paving, curbs, culverts, drainage pipe installation				1	bid
325,500	325,500				
Trenching					
Trenching in paved areas				500	foot
40	20,000				
Soil analyses and aeration				20	
cu.yard	200	4,000			
Wells/borings					
Dedicated soil vapor monitoring point				10	
point	5,000	50,000			
Well installation and development				6	
well	10,000	60,000			
Soil boring and initial water sample analyses				6	
well	8,000	48,000			
Pump test				6	
well	3,000	18,000			

Table 27. Alternative 6: Capital costs for source mass removal at the core of the Building 834 operable unit using soil vapor extraction enhanced by dewatering.

Unit type	Unit price (1994 $)	Total (1994 $)	Quantity
Well destruction			
well	10,000	20,000	2
Final confirmatory soil borings and analyses			
boring	3,000	30,000	10
Structures			
Equipment building			
each	300,000	300,000	1
Geotechnical			
each	10,000	10,000	1
Subtotal field costs		1,257,573	
Contractor overhead and profit (15% of subtotal field costs)		188,636	
Subtotal contractor field costs		1,446,209	
LLNL material procurement charge (MPC) (18% of contractor field costs)		260,318	
LLNL Protective Services			
Escort service (2 guards for 20 weeks)			
day	320	64,000	200
Total field costs (TFC)		1,770,527	
Professional environmental services			
Design		50,000	
Permitting		30,000	
Start-up labor and analyses		40,000	
SVE tests		20,000	
SVE performance evaluation		50,000	
Subtotal professional environmental services		190,000	
LLNL MPC (9.7% of professional environmental services)		18,430	
Total professional environmental services			

208,430

Table 27. Alternative 6: Capital costs for source mass removal at the core of the Building 834 operable unit using soil vapor extraction enhanced by dewatering.

	Unit price type	Total (1994 $)	Quantity	Unit
LLNL ERD team				
Full time employee	year	120,000	120,000	1
Total LLNL ERD team				
120,000				
LLNL technical support services				
LLNL Plant Engineering planning and Title I, II, and III services (33% of TFC)				
584,274				
Implementation of institutional controls				
50,000				
Total LLNL support services				
634,274				
Building ventilation system modification major equipment costs (MEC)				
Building 834A				1
each	10,000	10,000		
Building 834D				1
each	5,000	5,000		
Building 834J				1
each	4,500	4,500		
Building 834O				1
each	4,500	4,500		
Seal cracks/epoxy-coat floors				
20,000				
Total building ventilation retrofits				
44,000				
Remedial Design Report/Treatability study				1
each	300,000	300,000		
Total capital costs (TCC)				
3,077,231				
		Operation and Maintenance Costs		
Fixed annual O&M costs for SVE				
Electricity			64,700	kw
h	0.07	4,52		

Electrical capacity charge 8.2
kw 36 295
Project management 300
hour 75 22,500
System optimization, engineer 400
hour 75 30,000
Well field optimization, hydrogeologist 400
hour 68 27,200
Operating labor 250
hour 55 13,750

Table 27. Alternative 6: Capital costs for source mass removal at the core of the Building 834 operable unit using soil vapor extraction enhanced by dewatering.

Unit price	Total			
			Quantity	Unit type (1994 $) (1994 $)
Clerical			200	
hour	45	9,000		
SVE air permit compliance reporting (monthly)			12	
report	2,000	24,000		
Total fixed annual SVE O&M costs				
131,274				
Total present worth of fixed O&M for soil vapor extraction, years 1-5 (factor = 4.52)				
593,359				
Fixed annual O&M costs for dewatering				
Electricity			93,000	
kw h	0.07	6,510		
Electrical capacity charge			11.8	
kw	36	425		
Project management			200	
hour	75	15,000		
System optimization, engineer			300	
hour	75	22,500		
Well field optimization, hydrogeologist			300	
hour	68	20,400		
Operating labor			500	
hour	55	27,500		
Clerical			200	
hour	45	9,000		
Ground water treatment system analyses (water only)			12	
event	500	6,000		
Ground water treatment air permit compliance reporting (monthly)			12	
report	2,000	24,000		
Ground water discharge reporting (monthly)			12	
report	2,000	24,000		
Maintenance (10% of MEIC)				
37,207				

Total fixed annual dewatering and plume control O&M costs
192,542

Total present worth of fixed O&M for ground water
extraction, years 1-5 (factor = 4.52)
870,290

Total present worth of fixed O&M costs
1,463,650

Variable operating costs for source mass removal and plume control

Annual costs, year 1
SVE replacement of GAC 17,860 1b
2.30 41,078
Ground water treatment system replacement of vapor
GAC 3,440 1b
2.30 7,912
Ground water treatment system replacement of
aqueous GAC 40 1b
2.30 92

Table 27. Alternative 6: Capital costs for source mass removal at the core of the Building 834 operable unit using soil vapor extraction enhanced by dewatering.

	Unit price type	Total (1994 $)	Quantity	Unit	(1994 $)
SVE air sampling			36		
sample	100	3,600			
Ground water treatment system air sampling			36		
sample	100	3,600			
Total annual costs, year 1					
56,282					
Total present worth, year 1 (factor = 0.97)					
54,594					
Annual costs, year 2					
SVE replacement of GAC			3,040	1b	
2.30	6,992				
Ground water treatment system replacement of vapor					
GAC			1,720	1b	
2.30	3,956				
Ground water treatment system replacement of					
aqueous GAC			40	1b	
2.30	92				
SVE air sampling			36		
sample	100	3,600			
Ground water treatment system air sampling			36		
sample	100	3,600			

Total annual costs, year 2
18,240

Total present worth, year 2 (factor = 0.93)
16,963

Annual costs, year 3
SVE replacement of GAC 1,985
1b 2.30 4,566
Ground water treatment system replacement of vapor GAC 1,720
1b 2.30 3,956
Ground water treatment system replacement of aqueous GAC 40
1b 2.30 92
SVE air sampling 36
sample 100 3,600
Ground water treatment system air sampling 36
sample 100 3,600

Total annual costs, year 3
15,814

Total present worth, year 3 (factor = 0.90)
14,232

Annual costs, year 4
SVE replacement of GAC 860
1b 2.30 1,978
Ground water treatment system replacement of vapor GAC 1,720
1b 2.30 3,956

Table 27. Alternative 6: Capital costs for source mass removal at the core of the Building 834 operable unit using soil vapor extraction enhanced by dewatering.

Unit price type	(1994 $)	Total (1994 $)	Quantity	Unit
Ground water treatment system replacement of aqueous GAC			40	1b
2.30	92			
SVE air sampling			36	
sample	100	3,600		
GWT air sampling			36	
sample	100	3,600		

Total annual costs, year 4
13,226

Total present worth, year 4 (factor = 0.87)
11,507

Annual costs, year 5

SVE replacement of GAC			480		1b
2.30	1,104				
Ground water treatment system replacement of vapor GAC			1,720		1b
2.30	3,956				
Ground water treatment system replacement of aqueous GAC			40		1b
2.30	92				
SVE air sampling			36		
sample	100	3,600			
GWT air sampling			36		
sample	100	3,600			
Total annual costs, year 5					
12,352					
Total present worth, year 5 (factor = 0.84)					
10,376					
Total present worth of variable operating costs					
107,671					
Total present worth of fixed and variable O&M costs					
1,571,321					
		Ground water monitoring			
Annual costs, years 1-5					
Quarterly water level measurements			52		
well	55	2,860			
Quarterly ground water monitoring and analyses			28		
well	640	17,920			
Biannual ground water monitoring and analyses			7		
well	320	2,240			
Annual ground water monitoring and analyses			17		
well	160	2,720			
Maintenance of ground water sampling system			52		
well	430	22,360			
Quarterly monitoring report			4		
report	15,000	60,000			
Project management			500		
hour	75	37,500			
Hydrogeologist			200		
hour	68	13,600			

Table 27. Alternative 6: Capital costs for source mass removal at the core of the Building 834 operable unit using soil vapor extraction enhanced by dewatering.

Unit price	Total		Quantity	Unit
type	(1994 $)	(1994 $)		
Clerical			200	
hour	45	9,000		

Total annual costs, years 1-5
168,200

Total present worth, years 1-5 (factor = 4.52)
760,264

Annual costs, years 6-30
Quarterly water-level measurements 52
well 56 2,860
Annual ground water monitoring and analyses 52
well 160 8,320
Maintenance of ground water sampling system 52
well 430 22,360
Quarterly monitoring report 4
report 15,000 60,000
Project management 500
hour 75 37,500
Hydrogeologist 200
hour 68 13,600
Clerical 200
hour 45 9,000

Total annual costs, years 6-30
153,640

Total present worth, years 6-10 (factor - 3.80)
583,832

Total present worth, years 11-15 (factor = 3.20)
491,648

Total present worth, years 16-20 (factor = 2.69)
413,292

Total present worth, years 21-25 (factor = 2.27)
348,763

Total present worth, years 26-30 (factor = 1.91)
293,452

Total present worth, years 6-30
2,130,987

Total present worth of ground water monitoring for
30 years
2,891,251

Soil vapor monitoring

Annual costs, year 1
Quarterly soil vapor monitoring and analyses from
extraction wells 19
well 400 7,600

Table 27. Alternative 6: Capital costs for source mass removal at the core of the

Building 834 operable unit using soil vapor extraction enhanced by dewatering.

Unit type	Unit price (1994 $)	Total (1994 $)	Quantity
Quarterly shallow soil vapor point monitoring and analyses			10
point	400	4,000	
Total annual costs, year 1		11,600	
Total present worth, year 1 (factor = 0.97)		11,252	
Annual costs, years 2-5			
Biannual soil vapor monitoring and analyses from extraction wells			19
well	200	3,800	
Biannual shallow soil vapor point monitoring and analyses			10
point	200	2,000	
Total annual costs, years 2-5		5,800	
Total present worth, years 2-5 (factor = 3.55)		20,590	
Annual soil vapor monitoring and analyses from extraction wells			19
well	100	1,900	
Annual shallow soil vapor point monitoring and analyses			10
point	100	1,000	
Total annual costs, years 6-10		2,900	
Total present worth, years 6-10 (factor = 3.80)		11,020	
Annual costs, years 11-30			
Annual shallow soil vapor point monitoring and analyses			10
point	100	1,000	
Total annual costs, years 11-30		1,000	
Total present worth, years 11-15 (factor = 3.20)		3,200	
Total present worth, years 16-20 (factor = 2.69)		2,690	
Total present worth, years 21-25 (factor = 2.27)		2,270	

Total present worth, years 26-30 (factor = 1.91)
1,910

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Table 27. Alternative 6: Capital costs for source mass removal at the core of the Building 834 operable unit using soil vapor extraction enhanced by dewatering.

Unit type	Quantity	Unit price (1994 $)	Total (1994 $)
Total present worth for soil vapor monitoring for 30 years			52,932
Subtotal present worth of Alternative 6			7,592,735
LLNL General & Administrative Tax (7.5%)			569,455
Subtotal			8,162,190
LLNL Lab-Directed Research & Development Tax (6.0%)			489,731
Subtotal			8,651,921
Contingency (20%)			1,730,384
Total present worth of Alternative 6			10,382,306

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Table 28. ARARs for the selected interim remedy at the Building 834 operable unit.

Action	Source	Description	Application to the selected remedy
Extraction of soil vapor and monitoring of the dewatering of perched water-bearing zone	State: During and after completion of the selected interim remedy, Chapter 15, CCR, Title 23,	Requires effectiveness of remedial actions.	

concentrations of contaminants in in situ soil vapor and ground water will be measured.	Section 2550.7, 2550.10. (Applicable)	
Discharge of treated ground high quality surface water be maintained to Resolution 68-16 possible.	State: In the context of the selected interim remedy, this is applicable only to discharges of treated ground water from the misting towers. The compliance standards for discharge water are contained in the current Substantive Requirement for the Building 834 RWQCB for the Building 834 operable unit.	Requires that and ground water
	SWRCB the maximum extent (Antidegradation policy). (Applicable)	
Discharge of treated soil vapor nonvehicular sources of contaminants.	Local: During the selected interim remedy, contaminated soil vapor will be treated with GAC or equivalent technologies and discharged to the atmosphere. The compliance standards for treated soil vapor are contained in the current Authority To Construct and subsequent Permit to Operate issued by the SJUAPCD.	Regulates air
	San Joaquin Unified Air Pollution Control District (SJUAPCD) Rules and Regulations, Rules 463.5 and 2201. (Applicable)	

Table 28. (Continued)

Action	Description	Source	Application to the selected remedy

Disposition of hazardous waste hazardous wastes from generation through transportation, storage, and ultimate disposal.	For the selected interim remedy, this ARAR applies primarily to spent GAC vessels.	State: Health and Safety Code, Sections 25100-25395, CCR, Title 22, ch. 30: Minimum Standards for Management of Hazardous and Extremely Hazardous Wastes. (Applicable)	Controls point of accumulation, treatment,
Protection of endangered species facilities or practices contribute to the taking endangered or threatened plants, fish, or wildlife. implementation apply.	Prior to any well installation, facility contruction, or similar potentially discriptive activities, wildlife surverys will be conducted and mitigation measures implemented if required.	Federal: Endangered Species Act of 1973, 16 USC Section 1531 et seq. 50 CFR Part 200, 50 CFR Part 402 [40 CFR 257.3-2]. (Applicable) State: California Endangered Species Act, California Department of Fish and Game Sections 2050-2068. (Applicable)	Requires that not cause or of any species of NEPA requirements

Acronyms

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Acronyms

AOS	Adult On Site
ARARs	Applicable or Relevant and Appropriate Requirements
BAT	Best Available Technology
Cal-EPA	State of California, Environmental Protection Agency

CAREs	Citizens Against a Radioactive Environment
CCR	California Code of Regulations
CDF	California Department of Forestry
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CPF	Cancer Potency Factor
DCE	Dichloroethylene
DNAPLs	Dense Nonaqueous Phase Liquids
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
ECAO	Environmental Criteria Assessment Office
FFA	Federal Facility Agreement
FS	Feasibility Study
GAC	Granular Activated Carbon
GSA	General Services Area
HE	High Explosives
HEAST	Health Effects Assessment Summary Tables
HI	Hazard Index
HQ	Hazard Quotient
IRIS	Integrated Risk Information System
ISVRL	Interim Soil Vapor Restoration Level
LLNL	Lawrence Livermore National Laboratory
LNAPLs	Light Nonaqueous Phase Liquids
LOAEL	Lowest-Observed-Adverse-Effect-Level
MCLs	Maximum Contaminant Levels

NCP	National Contingency Plan
NEPA	National Environmental Policy Act

NOAEL	No-Observed-Adverse-Effect-Level
NPL	National Priorities List
O&M	Operations and Maintenance
OU	Operable Unit
PCE	Tetrachloroethylene
PEFs	Pathway Exposure Factors
PP	Proposed Plan
ppmv/v	Parts Per Million on a Volume-to-Volume Basis
PRGs	Preliminary Remediation Goals
QA	Quality Assurance
QC	Quality Control
Qt	Quaternary Terrace Deposits
RAGS	Risk Assessment Guidance for Superfund
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RES	Residential Exposure
RfD	Reference Dose
ROD	Record of Decision
RWQCB	Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
SITE	Superfund Innovative Technology Evaluation
SJUAPCD	San Joaquin Unified Air Pollution Control District
SVE	Soil Vapor Extraction
SVS	Soil Vapor Survey
SWRCB	State Water Resources Control Board
SWRI	Site Wide Remedial Investigation Report
T-BOS	Tetra 2-ethylbutylorthosilicate
TBC	To Be Considered
TBD	To Be Determined
TCA	Trichloroethane

TCE	Trichloroethylene
Tnbs1	Miocene Neroly Formation Lower Blue Sandstone
Tnbs2	Miocene Neroly Formation Upper Blue Sandstone
TPH	Total Petroleum Hydrocarbons
Tpsg	Pliocene Nonmarine Unit (Gravel Facies)
U.S. EPA	United States Environmental Protection Agency
UCLs	Upper Confidence Limits
U.S. DOE	United States Department of Energy
VOCs	Volatile Organic Compounds

LAWRENCE LIVERMORE NATL LAB (SITE 300) (USDOE)

Site Information:

Site Name: LAWRENCE LIVERMORE NATL LAB (SITE 300) (USDOE)
Address: LIVERMORE, CA

EPA ID: CA2890090002
EPA Region: 09

Record of Decision (ROD):

ROD Date: 01/29/1997
Operable Unit: 01
ROD ID: EPA/541/R-97/043

Media: Groundwater,Soil

Contaminant: 1,1,1-trichloroethane, 1,1-dichloroethylene, cis-1,2-dichloroethylene, acetone, benzene, bromodichloromethane, chloroform, tetrachloroethylene, trichloroethylene, trichlorofluoromethane, cadmium, copper, HMX, toluene, trichlorofluoroethane, xylenes, zinc, trimethlybenzene, methylene chloride, styrene, ethylbenzene.

Abstract: The Lawrence Livermore Laboratory (Site 300) is a U.S. Department of Energy (DOE)-owned experimental facility operated by the University of California. It is located 17 miles east-southeast of Livermore, California and is bordered by cattle-grazing land, a California Department of Fish and Game ecological preserve, an outdoor recreational facility, and a privately-owned high explosives testing facility. This document covers the General Services Area (GSA) of Site 300.Prior to the purchase of Site 300 land for development as a DOE experimental test facility in 1953, the area was used for cattle ranching and livestock grazing. Since the late 1950s, GSA facilities have been used as administration offices and equipment fabrication and repair shops that support Site 300 activities. Undetermined quantities of solvents containing trichloroethene (TCE), a suspected human carcinogen, and other volatile organic compounds (VOCs) were released to the ground as a result of past activities in the craft shops, equipment fabrication and repair facilities in the GSA.In 1982, DOE discovered contamination at the site and began an investigation. The site was placed on the National Priorities List in mid-1990.

Remedy: The major components of the selected remedy include: monitoring throughout the predicted 55 years of remediation, plus 5 years of post-remediation monitoring; contingency point-of-use (POU) treatment for existing off-site water supply wells; administrative controls to prevent human exposure by restricting access to or activities in contaminated areas, if necessary; soil vapor extraction (SVE) and treatment in the central GSA dry well source area; dewatering of the shallow water-bearing zone in the vicinity of the Building 875 dry well release area to enhance the effectiveness of SVE; and extraction and treatment of groundwater in the GSA until drinking water standards are met.

Text: Full-text ROD document follows on next page.

EPA/541/R-97/043

<IMG SRC 970430>

UCRL-AR-124061

Final Record of Decision for the General Services Area Operable Unit Lawrence Livermore National Laboratory Site 300

January 1997

Environmental Protection Department
Environmental Restoration Program and Division

Work performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

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Acronyms and Abbreviations

For the convenience of the reader, a reference list defining acronyms and abbreviations used throughout this document is presented after the Tables.

1. Declaration

1.1. Site Name and Location

The site described in this Record of Decision (ROD) is known as the General Services Area (GSA) operable unit (OU) located at Lawrence Livermore National Laboratory (LLNL) Site 300, Tracy, California. This OU is designated as OU-1 in the Site 300 Federal Facility Agreement (FFA) signed in June 1992.

1.2. Statement of Basis and Purpose

This decision document presents the selected remedial action for the GSA OU at LLNL Site 300. This remedial action was developed in accordance with the Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) and, to the extent practicable, the National Contingency Plan (NCP). This decision is based on the Administrative Record for this OU. The State of California Department of Toxic Substances Control (DTSC), Central Valley Regional Water Quality Control Board (CVRWQCB), and the U.S. Environmental Protection Agency (EPA) Region IX concur with the selected remedy.

1.3. Assessment of the Site

Based on the baseline risk assessment, actual or threatened releases of hazardous substances at this OU, if not addressed by implementing the response actions selected in this ROD, may present an imminent and substantial endangerment to public health and welfare, or the environment.

1.4. Description of the Selected Remedy

In June 1992, a FFA for the LLNL Site 300 Experimental Test Facility was signed by the regulatory agencies (U.S. EPA Region IX, DTSC, CVRWQCB) and the landowner (U.S. Department of Energy [DOE]). The FFA defines seven OUs and designates the GSA OU as OU-1. The GSA OU is located in the southeastern portion of Site 300 and was established to address soil and ground water contamination in the subsurface immediately beneath and approximately 2,300 ft downgradient of the GSA facilities. Currently, a stream-lined CERCLA process is being adopted for Site 300 cleanup. This process will not affect the GSA OU, which will proceed on the current FFA schedule.

Remedial actions for the GSA OU primarily target trichloroethylene (TCE) and other volatile organic compounds (VOCs) in ground water and soil beneath the GSA. The risks associated with subsurface contamination at the GSA OU are: 1) potential ingestion of ground water containing VOCs, and 2) onsite worker inhalation exposure to TCE volatilizing from subsurface soil (0.5-12.0 ft) to indoor air within Building 875.

Three remedial alternatives for the GSA OU were presented in the Final General Services Area Feasibility Study (Rueth and Berry, 1995). These remedial alternatives were evaluated by the supervising Federal and State regulatory agencies and presented to the public. DOE and the

regulatory agencies, the U.S. EPA, and the State of California DTSC and CVRWQCB agreed that Alternative 3b provides the most effective means of remediating VOCs in soil and ground water to levels protective of human health and the environment. Alternative 3b is presented as the selected remedy for the GSA OU. The major components of the selected remedy include:

- Monitoring throughout the predicted 55 years of remediation, plus five years of post-remediation monitoring.

- Contingency point-of-use (POU) treatment for existing offsite water-supply wells.

- Administrative controls to prevent human exposure by restricting access to or activities in contaminated areas, if necessary.

- Soil vapor extraction (SVE) and treatment in the central GSA dry well source area. SVE will be conducted to: 1) reduce VOC concentrations in soil vapor to levels protective of ground water, 2) remediate dense non-aqueous phase liquids (DNAPLs) in the soil, and 3) mitigate VOC inhalation risk inside Building 875.

- Dewatering of the shallow water-bearing zone in the vicinity of the Building 875 dry well release area to enhance the effectiveness of SVE by exposing a larger soil volume to vapor flow.

- Extraction and treatment of ground water in the GSA until drinking water standards (Maximum Contaminant Levels, or MCLs) are reached in both the regional and shallow aquifers. Modeling indicates ground water extraction will reduce ground water VOC concentrations in the eastern and central GSA to the remediation goal (MCLs) within 10 and 55 years, respectively.

The 1995 present-worth cost of the selected remedy is estimated to be approximately $18.90 million. This estimate assumes: 1) 10 years of SVE, and 55 years of ground water extraction in the central GSA, 2) 10 years of ground water extraction in the eastern GSA debris burial trench area, and 3) 60 years of ground water monitoring. These time and cost estimates do not include the development, testing, or utilization of any future innovative technologies, which, if available, could be used to expedite cleanup and/or reduce long-term costs.

DOE and the regulatory agencies will jointly determine the scope and schedule of all required post-ROD documents and reports (up to the Final Remedial Design document), as well as schedules for implementing the selected remedy.

1.5. Statutory Determinations

The selected GSA remedial action is protective of human health and the environment and complies with Federal and State applicable or relevant and appropriate requirements (ARARs). The selected remedy provides both short- and long-term effectiveness in meeting ARARs and protecting human health and the environment. This remedy satisfies the statutory preference for remedies that employ treatment technologies that reduce contaminant toxicity, mobility, or

volume as a principal element. The remedial action is readily implementable and provides the most cost-effective means of remediating VOCs in the affected media available at this time.

The supervising Federal and State regulatory agencies participated in the evaluation of the proposed remedial alternatives and concur with the selected remedy. Public input was considered and used, as appropriate, in the selection and development of the final remedial action.

A review will be conducted within five years and every five years after commencement of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

1.6. Acceptance of the Record of Decision by Signatory Parties

Each undersigned representative of a Party certifies that he or she is fully authorized to enter into the terms and conditions of this agreement and to legally bind such party to this agreement.

IT IS SO AGREED:
<IMG SCR 97043A>

2. Decision Summary

2.1. Site Name, Location, and Description

Site 300, a DOE-owned experimental test facility operated by the University of California, is located in the southeastern Altamont Hills of the Diablo Range, about 17 mi east-southeast of Livermore and 8.5 mi southwest of Tracy, California (Fig. 1). The site is bordered by cattle grazing land, a California Department of Fish and Game ecological preserve, an outdoor recreational facility, and a privately owned high explosives (HE) testing facility. For the purpose of this ROD, it is assumed that Site 300 will remain under the continued control of DOE for the foreseeable future.

The GSA OU is located in the southeastern part of Site 300, and was established to address soil and ground water contamination in the subsurface below the OU (Fig. 2).

2.2. Site History and Summary of Enforcement

Prior to the purchase of Site 300 land for development as a DOE experimental test facility in 1953, the GSA was used for cattle ranching and livestock grazing. Since the late 1950s, the GSA facilities have been used as administration offices and equipment fabrication and repair shops that support Site 300 activities. Site 300 was in operation prior to the enactment of the Resource Conservation and Recovery Act of 1976.

Undetermined quantities of solvents containing TCE, a suspected human carcinogen, and other VOCs were released to the ground as a result of past activities in the craft shops, equipment fabrication and repair facilities in the GSA, and are in the soil/rock and ground water in the area. Other chemical compounds commonly detected in soil/rock and ground water in the GSA include tetrachloroethylene (PCE), 1,2-dichloroethylene (DCE), 1,1-DCE, and freon compounds.

In 1982, DOE discovered contamination at the site and began an investigation under CVRWQCB guidance. All investigations of potential chemical contamination at Site 300 were conducted under the over-sight of the CVRWQCB until August 1990, when Site 300 was placed on the National Priorities List. Since then, all investigations have been conducted in accordance with CERCLA under the guidance of three supervising regulatory agencies: the U.S. EPA Region IX, the CVRWQCB, and the DTSC. The DOE entered into a FFA with these agencies in June 1992.

In accordance with CERCLA requirements and the terms of the Site 300 FFA, DOE released the Final Site-Wide Remedial Investigation (SWRI) report (Webster-Scholten, 1994), the Final General Services Area Operable Unit Feasibility Study (FS) (Rueth and Berry, 1995) and the Proposed Plan for Remediation of the Lawrence Livermore National Laboratory Site 300 General Services Area (U.S. DOE/LLNL, 1996). The SWRI documented environmental investigations that occurred at Site 300 since 1982, and characterized the extent of VOCs in the subsurface and the Site 300 hydrogeology. The GSA FS developed and evaluated alternatives for remedial action at the GSA. The SWRI and the FS form the basis for selecting technologies

to remediate the GSA OU. The Proposed Plan for remediation of the GSA OU summarized site conditions and remedial alternatives, and presented the preferred remedy.

CERCLA Removal Actions were initiated in the eastern and central GSA in 1991 and 1993, respectively. To date, 35,387 grams (79 lb) of VOCs have been removed from the GSA through ground water and soil vapor extraction as part of these Removal Actions.

2.3. Highlights of Community Participation

The SWRI and the FS for the GSA OU were made available to the public in April 1994 and

October 1995, respectively. The Proposed Plan was released to the public in March 1996. This ROD presents the selected remedial action for the GSA OU. All documents were prepared in compliance with CERCLA as amended by SARA. The decision for this site is based on the Administrative Record, which is available at the Information Repository at the LLNL Visitors Center and the Tracy Public Library.

A public review and comment period on the preferred remedial alternative began April 10, 1996, and ended May 10, 1996. Interested members of the public were invited to review all documents and comment on the considered remedial alternatives by writing to the Site 300 Remedial Project Manager or by attending a public meeting on April 24, 1996, at the Tracy Inn in Tracy, California. At this meeting, representatives from DOE, University of California, U.S. EPA, and the State of California discussed the proposed remediation plan and addressed public concerns and questions. Questions and comments from the public are presented and addressed in the Responsiveness Summary of this ROD.

2.4. Scope and Role of the GSA OU

The Site 300 FFA defines the following seven OUs at Site 300:

- OU-1, GSA.
- OU-2, Building 834.
- OU-3, Pit 6.
- OU-4, HE Process Area Building 815.
- OU-5, Building 850/Pits 3 and 5.
- OU-6, Building 854.
- OU-7, Building 832 Canyon.
- OU-8, Site 300 Monitoring.

Investigations at the GSA OU address VOCs in soil/rock and ground water released to the environment as a result of past activities in the GSA craft shops, and equipment fabrication and repair facilities. The principal potential threats to human health and the environment are: 1) ingestion of VOCs in ground water, and 2) exposure to VOC vapors volatilizing from shallow soil into Building 875.

This ROD addresses both the potential human health ingestion risk posed by VOCs in ground water, as well as the inhalation risk posed by VOCs in the vadose zone at the GSA OU. The purpose of the selected remedy is to protect human health and the environment by reducing VOC concentrations in soil vapor and ground water and controlling VOC migration.

2.5. Site Characteristics

Since environmental investigations began at the GSA in 1982, 75 exploratory boreholes have

been drilled and 98 ground water monitor wells have been completed. Details of the geology and hydrogeology of the GSA OU, as well as environmental investigations conducted in this OU are presented in Chapter 14 of the Site 300 SWRI. Three water-bearing zones or hydrogeologic units have been identified (Fig. 3):

- Qt-Tnsc l Hydrogeologic Unit: This shallow water-bearing zone occurs beneath the central GSA portion of the OU and is composed of stratigraphic units Qt (terrace alluvium), Tnbs 2 (Neroly Formation-Upper Blue Sandstone), and Tnsc l (Neroly Formation-Siltstone/Claystone). Depending on topography, depth to water is approximately 10 to 20 ft beneath the ground surface. As a result of past releases, this shallow aquifer contains TCE and other VOCs. The VOC plume in this shallow aquifer is separated from the regional aquifer by a 60- to 80-ft thick aquitard (Tnsc l) in most of the central GSA. Ground water data indicate that the VOC plume in the shallow aquifer has not affected the regional aquifer in this area. Ground water in this shallow aquifer flows south-southeast with an estimated flow velocity of 0.09 to 3 ft/day.

- Tnbs 1 Hydrogeologic Unit (Regional Aquifer): The regional aquifer occurs in the lower Neroly Formation (Tnbs 1). This aquifer is encountered 35 to 145 ft below the ground surface under confined to semi-confined conditions in the central GSA. Ground water flow in this unit is to the south-southeast at a flow velocity of 0.3 ft/day.

- Qal-Tmss Hydrogeologic Unit: This hydrogeologic unit is composed of the stratigraphic units: Qal (alluvium), Tnsc 1, Tnbs 1, and Tmss (Cierbo Formation). For the most part, the Tnsc 1 aquitard is absent in the eastern GSA, and the shallow water-bearing zone (Qal) is in hydraulic communication with the underlying regional aquifer (Tnbs l). As a result, some contamination has migrated downward from the shallow-water bearing zone into the regional aquifer. Ground water flow in the alluvium (Qal) and shallow Tnbs 1 bedrock is eastward, turning north to follow the trend of the valley. Although the flow velocity is dependent on local hydraulic conductivity, the maximum flow velocity is estimated to be about 200 to 1,200 ft/yr.

2.5.1. Chemical Releases

Historical information and analytical data suggest that VOCs, in the dissolved form and/or as DNAPLs, were released to the ground in wastewater from the craft and repair shops, as

leaks/spills from solvent storage tanks or drums, and associated with debris buried in trenches in the eastern GSA in the 1960s and 1970s. These releases include:

- VOCs in rinse-, process-, and wash-water discharged to four dry wells from the central GSA craft and repair shops. Based on soil and ground water analytical data, the greatest VOC mass is concentrated in the vicinity of the Building 875 former dry wells.

- VOCs released to the ground from a decommissioned drum storage rack north of

Building 875.

- VOCs in rinse water discharged from a steam cleaning/sink area east of Building 879.
- VOCs associated with craft shop debris buried in trenches in the eastern GSA.

The confirmed release sites for the central and eastern GSA are shown in Figures 4 and 5. The quantity of TCE released in these areas greatly exceeds that of other VOCs.

2.5.2. VOCs in Ground Water

TCE is the most prevalent VOC in ground water, typically comprising 85 to 95% of the total VOCs detected. Other VOCs that have been detected include PCE, 1,2-DCE, 1,1-DCE, 1,1,1-trichloroethane, acetone, benzene, bromodichloromethane, chloroform, ethylbenzene, Freon 113, toluene, and xylenes (total isomers) (Table 1).

Detected concentrations of ethylbenzene, toluene, and xylene have decreased over time. Toluene, ethylbenzene, and xylenes have not been detected in ground water from any GSA wells in over 2.5 years. The last detections of these compounds occurred in 1994 when toluene was detected in well W-875-02 at a concentration of 0.5 µg/L and xylene was detected in well W-7N at a concentration of 0.96 µg/L. No toluene, ethylbenzene, or xylenes have been detected in any other GSA wells for 3.5 years or more. Therefore, these constituents are no longer considered contaminants of concern. The CVRWQCB believes that it is appropriate to continue to monitor for these constituents, but at a reduced frequency. The extent and frequency of monitoring for these constituents will be addressed in the Remedial Design document.

The highest ground water VOC concentrations in the central GSA have been detected in the vicinity of former dry well pad south of Building 875 (Figs. 4 and 6). TCE has been detected in ground water in concentrations up to 240,000 micrograms per liter (µg/L) in a bailed ground water sample collected from well W-875-07 in March 1993. This concentration suggests that TCE is present as residual DNAPL in the subsurface. As of third quarter 1994, the maximum TCE concentration in ground water samples collected from the Building 875 dry well pad area was 10,000 µ/L in well W-71 (Fig. 6). In general, if a ground water VOC concentration is 1 to 10% of the solubility of that VOC in ground water, a DNAPL may be present. Because the aqueous solubility of TCE is 1,100,000 µg/L, TCE concentrations in the range of 11,000 to 110,000 µg/L or greater may indicate DNAPL. The only wells in the GSA where ground water sample data indicate the possible presence of DNAPLs (TCE concentrations > 11,000 µg/L) are wells W-875-07, -08, -09, -10, -11, -15, and W-7I. As shown in Figure 6, these wells are all located in the Building 875 dry well pad area in the central GSA. The source of DNAPLs in this area was the waste water disposed in the two former dry wells, 875-S1 and 875-S2, located south of Building 875 (Fig. 4). Based on soil sample data from boreholes drilled prior to installation of the dry well pad wells, the bulk of TCE contamination in the dry well pad area is concentrated at

a depth of 20 to 35 ft near the contact between the Tnbs 2 water-bearing zone and the underlying Tnsc 1 confining layer. These data support a DNAPL-type scenario where TCE, which is denser than water, would tend to sink to the lowest point possible in a water-bearing unit, such as the contact between the water-bearing zone and an underlying confining layer that prevents the further downward migration of contaminants.

No other wells in the GSA have contained VOCs in ground water in concentrations indicative of DNAPLs, including wells located at other source areas and the two wells (W-7F and W-875-03) located within 50 to 75 ft of the dry well pad. We have therefore concluded that the DNAPLs are confined to the Building 875 dry well pad area in the central GSA.

As shown in Figure 6, a VOC ground water plume in the Qt-Tnsc 1 shallow aquifer extends from the Building 875 dry well pad and Building 872 and Building 873 dry wells into the Corral Hollow Creek alluvium. There is a smaller ground water plume with significantly lower VOC concentrations to the north associated with the drum storage rack and steam cleaning release sites. Based on ground water data collected from the Tnbs 1 regional aquifer, the VOC plumes appear to be confined to the Qt-Tnsc 1 hydrogeologic unit in this area, where the Tnsc 1 confining layer prevents the downward migration of contaminants. West of the sewage treatment pond, TCE has been detected in ground water in the regional aquifer (Fig. 7) where the Tnsc 1 confining layer is absent. The low TCE concentrations have generally been decreasing in the regional aquifer in this area since 1990.

In the eastern GSA, the highest VOC concentrations in ground water occur in the vicinity of the debris burial trench area (Fig. 8). TCE has been detected in ground water in concentrations up to 74 µg/L in this area. A VOC ground water plume extends eastward from the debris burial trench area and has migrated northward in the Corral Hollow alluvium. The plume with total VOC concentrations exceeding 5 µg/L currently extends approximately 550 ft from the debris burial trench release area. TCE has also been detected at low concentrations in ground water in the regional aquifer in the vicinity of the debris burial trenches (Fig. 9). TCE in the regional aquifer in this area is generally limited to portions of the regional aquifer which directly underlie the contaminated shallow water-bearing zone. The maximum VOC concentrations in ground water as of fourth quarter 1995 were 20 µg/L in the shallow water-bearing zone and 19 µg/L in the regional aquifer.

Further details on the extent of VOCs in ground water in the GSA can be found in Section 14-4.5, Chapter 14 of the Site 300 SWRI (Webster-Scholten, 1994), and Section 1.4.7 of the GSA FS (Rueth and Berry, 1995).

2.5.3. VOCs in SoiL/Rock

The highest TCE concentrations in soil/rock (up to 360 milligrams per kilogram [mg/kg]) in the central GSA were detected in the vicinity of the Building 875 former dry wells 875-S1 and 875-S2 at a depth of 20 to 35 ft near the contact between the Tnbs 2 water-bearing zone and the

underlying Tnsc 1 confining layer. Also, low concentrations of VOCs were detected in soil/rock samples collected from boreholes in the vicinity of the other four confirmed release sites in the central GSA: the decommissioned solvent drum rack, dry wells 872-S and 873-S, and the Building 879 steam-cleaning facility. VOC concentrations ranged from 0.0002 mg/kg to 0.9 mg/kg in these samples collected in 1989.

TCE, PCE and 1,2-DCE have been detected in concentrations up to 0. 19 mg/kg in borehole soil samples collected in 1989 in the vicinity of the debris burial trenches in the eastern GSA.

Further details on the extent of VOCs in soil/rock in the GSA are described in Section 14-4.3 , Chapter 14 of the Site 300 SWRI (Webster-Scholten, 1994) and Section 1.4.6 of the GSA FS (Rueth and Berry, 1995).

2.5.4. VOCs in Soil Vapor

Extensive soil vapor surveys, including both active and passive techniques, were conducted between 1988 and 1994 to: 1) assist in the identification of release sites, 2) determine the extent of VOC contamination, and 3) monitor the progress of soil vapor remediation efforts.

Further details on the extent of VOCs in soil vapor in the GSA can be found in Section 14-4.2, Chapter 14 of the Site 300 SWRI (Webster-Scholten, 1994), and Section 1.4.3 of the GSA FS (Rueth and Berry, 1995).

2.6. Risk Assessment

The baseline risk assessment provides the basis for taking action and identifies the potential exposure pathways that need to be addressed by the remedial action. It serves as the baseline to indicate what potential risks might exist if no action were taken at the site. This section of the ROD reports the results of the baseline risk assessment conducted for this site. Additional details may be found in Chapter 6 of the Site 300 SWRI (Webster-Scholten, 1994), and Section 1.6 of the GSA FS (Rueth and Berry, 1995).

The baseline risk assessment evaluated potential present and future public health and ecological risks associated with environmental contamination in the GSA OU, using the assumption that no cleanup or remediation activities would take place at the site. Selection of a specific remediation strategy is based in part on the extent to which it can reduce potential public health and ecological risks.

The baseline risk assessment presented in the SWRI consists of six components:

- Identification of chemicals of potential concern.
- Identification of the contaminated environmental media.
- Estimation of potential exposure-point concentrations of contaminants.
- Human exposure and dose assessment.
- Toxicity assessment.
- Risk characterization.

Each of these components are summarized in the following sections. Additional details are available in the Site 300 SWRI and in the GSA FS.

2.6.1. Identification of Chemicals of Potential Concern

Tables 1 through 4 present the chemicals of potential concern identified in the GSA OU. Details of the methodology used to identify these contaminants are described in the Site 300 SWRI (Webster-Scholten, 1994).

2.6.2. Identification of Contaminated Environmental Media

Based on the assessment of the nature and extent of contamination obtained during site characterization, contaminants of potential concern were identified in different environmental media in the GSA OU: ground water, surface soil, subsurface soil, and soil vapor (Tables 1 through 4, respectively). The 95% upper confidence limit (UCL) of the mean concentration and exposure-point concentrations of each contaminant are listed in Table 5.

2.6.3. Estimates of Potential Exposure-Point Concentrations

Conceptual models were developed to identify the probable migration processes and routes of the chemicals of concern from release sites and source media in the GSA OU to selected potential exposure points. The conceptual models provided the basis for selection of the quantitative models used to generate estimates of contaminant release rates and potential exposure-point concentrations. The exposure-point concentrations were used to estimate the magnitude of potential exposure to contaminants in the baseline risk assessment. The release areas, migration processes, and exposure points identified in the GSA OU are given in Table 5.
In addition, this table lists the mathematical models used to estimate contaminant migration rates and the calculated exposure-point concentrations for the chemicals of concern in each environmental medium.

Direct measurements of VOC soil flux were obtained in the GSA that were used in a mathematical model to estimate exposure-point concentrations of contaminants in the atmosphere when VOCs volatilize from subsurface soil in the vicinity of three exposure locations in the GSA OU: 1) the Building 875 dry well area, 2) the central GSA, and 3) the

eastern GSA. A mathematical model was applied, using subsurface soil (0.5 to 12.0 ft) VOC concentrations in the vicinity of the Building 875 dry well pad, to estimate the potential exposure-point concentrations of contaminants in indoor air of Building 875 when VOCs volatilize from subsurface soil underneath the building and diffuse into the building. Measurements of actual VOC concentrations inside Building 875 were not conducted or used in the estimate of exposure-point concentrations in indoor air as the work activities which still occur in Building 875 involve the use of VOC-containing solvents. Therefore, it would be difficult, if not impossible to distinguish between VOC vapors migrating from the subsurface through the concrete floor and those present in indoor air as a result of current work activities utilizing solvents. As a result, we took a health conservative approach and utilized soil sample data from the Building 875 dry well pad approximately 35 ft from the building to calculate exposure-point concentrations inside Building 875.

In addition, estimates were made of the concentrations of surface soil (0 .5 ft) contaminants that are bound to resuspended particles throughout the OU. The 95% UCLs of the mean contaminant concentration in the surface soil, and site-specific data on total resuspended

particulates were used to estimate the concentration of surface soil contaminants bound to resuspended particles throughout the OU. For direct dermal contact and incidental ingestion, the exposure-point concentrations of contaminants in surface soil are the same as the 95% UCLs of the mean concentration of the chemicals.

The fate and transport of VOCs in ground water were considered for both the central and eastern GSA, as well as a combined central and eastern GSA plume. For the central GSA, exposure-point concentrations were estimated at the site boundary and then modeling was used to estimate exposure-point concentrations at the California Department of Forestry water-supply well, CDF-1, located approximately 300 ft southeast of the Site 300 boundary. For the eastern GSA, exposure-point concentrations were estimated for a theoretical well at the site boundary and for two plumes commingling at well CDF-1; these concentrations were modeled to downgradient water-supply well SR-1 (Fig. 10).

2.6.4. Human Exposure and Dose Assessments

Exposure scenarios and pathway exposure factors (PEFs) used to assess the magnitude of potential human exposure and dose are described below.

2.6.4.1. Exposure Scenarios

The exposure scenarios used to evaluate potential adverse health effects associated with environmental contamination in the GSA OU were developed based on assumptions about present and future uses of the site and lands in the immediate vicinity.

Two principal scenarios were developed to evaluate potential human exposure to environmental contaminants in the GSA OU. The first of these scenarios pertains to adults working in the GSA OU. This scenario addresses potential health risks attributable to

contaminants in subsurface soil and surface soil, where an adult on site (AOS) is presumed to work in the immediate vicinity of the contamination over their entire period of employment at the site (25 years). Subsurface soil contaminants can volatilize into air, where they may be inhaled by individuals who work in the vicinity of the contamination. Surface soil contaminants bound to resuspended soil particulates may also be inhaled by individuals in the course of work-related activities at the site. In addition, we evaluated AOS exposure as a consequence of dermal absorption and incidental ingestion of contaminants on surface soil.

The second scenario pertains to residential exposures (RES), which are associated with use of contaminated ground water from: 1) theoretical wells installed at the central and eastern GSA site boundaries, 2) well CDF-1, and 3) well SR-1. The identification and selection of exposure pathways related to residential use of contaminated ground water were based on the assumption that well water will be used to supply all domestic water needs, such as those associated with showering or bathing, cooking, dishwashing, and laundry. We also assumed that contaminated ground water will be used to irrigate home gardens, and will be supplied to dairy and beef cattle raised for domestic consumption. Accordingly, we evaluated potential residential exposure to contaminants in ground water at theoretical wells and existing wells CDF-1 and SR-1 due to: 1) direct ingestion of water, 2) inhalation of VOCs that volatilize from water to indoor air, 3) dermal absorption of contaminants while showering or bathing, 4) ingestion of fruits and vegetables grown using contaminated ground water, and 5) ingestion of meat and milk from

homegrown beef and dairy cattle supplied with contaminated ground water. For the purpose of the risk assessment, we assume residents could be exposed to contaminants in ground water for 30 years.

2.6.4.2 Pathway Exposure Factors

To estimate the magnitude of potential human exposure to contaminants in the GSA OU, we developed PEFs, which convert the exposure-point concentrations of contaminants into estimates of average contaminant intake over time (the chronic daily intake, or CDI). These PEFs are based on a series of reported and/or assumed parameters regarding current and potential land use patterns in and around the GSA OU, residential occupancy patterns, and length of employment. PEFs also account for a number of physiological and dietary factors such as the daily ingestion rates of water and homegrown fruits, vegetables, beef, and milk; daily breathing rate; and surface area of exposed skin.

Reference documents for PEF data that were used to evaluate potential adult onsite and residential exposure to contaminants and summary values are listed in Table 6.

2.6.5. Toxicity Assessment

For each location with environmental contamination, we began by identifying those chemicals of concern that are classified by the U.S. EPA (U.S. EPA, 1992a) or by the State of California EPA (1992) as carcinogens. This classification is based on data from

epidemiological studies, animal bioassays, and in vivo and in vitro tests of genotoxicity.

2.6.5.1. Cancer Potency Factors

The Cancer Potency Factors (CPFs) used in our estimations of cancer risk were obtained from values published in either the Integrated Risk Information System (IRIS) (U.S. EPA, 1992b), the Health Effects Assessment Summary Tables (U.S. EPA, 1992a,c), or by the State of California, EPA (1992). CPFs for TCE and PCE were also provided by Region IX of the U.S. EPA (1993a). All CPFs were derived using versions of the linearized, multistage dose-response model (U.S. EPA, 1989a,b); generally, the dose- and tumor-incidence data used in the model are from animal bioassays. For contaminants of potential concern at Site 300, the exceptions are cadmium, benzene, and beryllium, where human tumor data are available. The model calculates the potential increased cancer risk, where increased risk is linearly related to dose for low-dose levels typical of environmental exposure. Use of animal bioassay data to predict human turnorigenic response assumes that animals are appropriate models of human carcinogenic response, and that the dose-response relationships observed in high-dose animal bioassays can be extrapolated linearly to the low doses generally associated with human exposure to environmental contaminants. When CPFs were available for a particular contaminant from both a U.S. EPA source and the State of California, the highest potency values were used.

Reference documents for CPFs (slope factors) used to calculate cancer risks in our evaluation are listed in Table 6.

2.6.5.2. Reference Dose

The reference doses (RfDs) used to evaluate potential noncarcinogenic adverse health effects were based, when possible, on long-term (i.e., chronic) exposures, and were derived by dividing an experimentally-determined no-observed-adverse-effect-level or lowest-observed-adverse-effect-level (each has units of mg/[kg • d]) by one or more uncertainty factors (U.S. EPA, 1992a,b,c). Each of these uncertainty factors has a value that ranges from I to 10 (U.S. EPA, 1992a,b,c). Pathway-specific RfDs were used, when available (U.S. EPA, 1992a,b,c; Cal-EPA, 1992), to calculate a corresponding Hazard Quotient (HQ). If pathway-specific RfDs were not available, the published RfDs (typically developed for oral exposures) were used to calculate an HQ for all exposure pathways.

Reference documents and reference doses used to calculate noncancer hazard indices in our evaluation are listed in Table 6.

2.6.6. Risk Characterization

The risk assessment was performed in accordance with Risk Assessment Guidance for Superfund (U.S. EPA, 1989a,b). Carcinogenic risks, an evaluation of potential noncarcinogenic exposure health hazards, and the additivity of response are described below.

2.6.6.1. Carcinogenic Risks

For carcinogens, we calculated the potential incremental cancer risk associated with long-term exposure to chemicals in surface soil, subsurface soil, and ground water. For each chemical at each exposure location, the total risk attributable to that chemical was estimated by multiplying each pathway-specific intake (e.g., the dose due to ingestion of water or to inhalation of contaminants that volatilize from water to indoor air) by the corresponding pathway-specific CPF. The products of each pathway-specific intake and pathway-specific CPF were summed to obtain the potential incremental cancer risk for a specific chemical. Parallel sets of calculations were completed for all chemicals at each exposure location, then values of chemical-specific risk from all chemicals were summed to yield an estimate of total incremental risk for exposures associated with a given location.

2.6.6.2. Evaluation of Hazard from Exposure to Chemicals that Cause Noncancer Health Effects

For chemicals of potential concern that are not classified as carcinogens, and for those carcinogens known to cause adverse health effects other than cancer, the potential for exposure to result in noncarcinogenic adverse health effects was evaluated by comparing the CDI with a RfD. When calculated for a single chemical, this comparison yields an HQ. For each chemical at each location, path way-specific HQs were summed (where applicable) to obtain an HQ estimate for a given chemical. We then summed all HQs from all chemicals to yield a hazard index (HI) estimate for exposures associated with a given location.

2.6.6.3. Additivity of Response

In every location at or near the GSA OU where cancer risk and noncancer HQs were calculated, CDIs were estimated for exposures attributable to multiple pathways for each of several contaminants. As noted previously, the total potential cancer risk and/or total HI were estimated by summing risk or HQs for all contaminants at a given location, where each chemical-specific estimate of risk or hazard represents exposures from multiple pathways. Implicit in the summation of risk and hazard is the assumption that the effects of exposure to more than one chemical are additive. This simplifying assumption does not consider similarities or differences in target organ toxicity, mechanism(s) of action, or the possibility of synergistic or antagonistic effects of different chemicals in the mixture.

2.6.7. Summary of Human Health Baseline Risks and Hazards Associated with Contaminants

Estimated baseline risks and hazards for the GSA OU were evaluated for adults on site exposures and residential exposures, as well as additive potential risk. These are described below, followed by a brief discussion of uncertainty.

2.6.7.1. Adult Onsite Exposures

The AOS exposure scenario addresses potential health risk attributable to contaminants in

soil, where an AOS is presumed to work in the immediate vicinity of the contamination over the entire period of employment at the site (25 years).

We evaluated potential AOS exposure to contamination by calculating the associated risk and hazard for two scenarios. The first of these scenarios pertains to potential AOS exposure to contaminated subsurface soil through inhalation of VOCs volatilizing from subsurface soil to air.
The second scenario pertains to potential AOS exposure to contaminated surface soil from inhalation of resuspended particulates, dermal absorption of contaminants following direct contact with contaminated soil, and incidental ingestion.

Risk and hazard associated with AOS exposure to contaminated subsurface soil through inhalation of VOCs volatilizing from subsurface soil (0.5 to 12.0 ft) to ambient air was evaluated
in the vicinity of three exposure locations in the GSA OU: 1) the Building 875 dry well area, 2) the central GSA, and 3) the eastern GSA. Individual potential excess lifetime cancer risks were 2 x 10 -7 for the Building 875 area, 7 x 10 -7 for the central GSA, and 2 x 10 -7 for the eastern GSA. The estimated noncancer HIs were 6.2 x 10 -3 for the Building 875 area, 1.2 x 10 -3 for the central GSA, and 1.3 x 10 -3 for the eastern GSA.

The potential excess lifetime cancer risk and noncancer HIs for the AOS exposure to contaminants volatilizing from subsurface soil to ambient air are within the acceptable range (cancer risk < 10 -6 and HI <1) specified by the NCP (U.S. EPA, 1990a).

Risk and hazard were also evaluated for AOS inhalation exposure to VOCs volatilizing from contaminated subsurface soil underneath Building 875 and diffusing into the building. The exposure scenario for an AOS working inside Building 875 resulted in estimates of individual potential excess lifetime cancer risk (1 x 10 -5) and noncancer HI (3 X 10 -1). While the

noncancer HI for this scenario is within acceptable limits (HI <1), the potential excess lifetime
cancer risk is within the range (between 10 -4 and 10 -6) where risk management measures are necessary.

The baseline evaluation of risk and hazard associated with AOS exposure to surface soil contaminants yielded estimates of individual excess lifetime cancer risk of 2 X 10 -7 for inhalation of resuspended particulates and 2 x 10 -10 for ingestion and dermal absorption of surface soil contaminants. The corresponding HIs are 5.6 x 10 -5 for inhalation and 8.5 X 10 -3 for ingestion and dermal absorption. The potential excess lifetime cancer risk and noncancer HIs
for the AOS exposure to surface soil contaminants are within the acceptable range (cancer risk of
<10 -6 and HI <1) specified by the NCP (U.S. EPA, 1990a).

Reference documents for calculations and estimates of potential cancer risk and hazard index
and the results are summarized in Table 6.

2.6.7.2. Additive Risk and Hazard for Adults Onsite

Adults working outdoors in the GSA OU could be exposed simultaneously to contaminants

in surface soil (by inhalation of resuspended particulates, and ingestion and dermal absorption of surface soil contaminants) as well as by inhalation of the VOCs that volatilize from subsurface soil. The vicinity of the central GSA was selected for our calculations of additive risk and HI associated with AOS exposures because our calculations indicated higher levels of cancer risk and HI for this location than for exposures associated with the Building 875 dry well area and the eastern GSA. Because the Building 875 dry well area, central GSA, and eastern GSA are separated by approximately 200 ft, we did not examine concurrent exposures to VOCs from the three sources.

Table 6 presents the potential additive individual excess lifetime cancer risk and HI estimates for AOS exposures in the GSA OU. The values given in Table 6 indicate an estimated total additive cancer risk of 9 X 10 -7 and a total additive HI of 9.7 x 10 -3.

The potential additive individual excess cancer risk and additive noncancer HIs for the AOS exposure in the GSA OU are within the acceptable range (cancer risk <10 -6 and HI <1) specified by the NCP (U.S. EPA, 1990a).

2.6.7.3. Residential Exposures

Risk and hazard were evaluated for potential RES use of contaminated ground water at: 1) hypothetical wells located at the site boundary near the Building 875 dry wells and the eastern GSA debris burial trenches, and 2) at existing water-supply wells CDF- 1 and SR- 1 -

We calculated the risk and hazard associated with potential RES use of contaminated ground water from a hypothetical water-supply well located at the site boundary nearest to the Building 875 dry wells. The individual excess lifetime cancer risk attributable to the potential use of ground water at this location is 7 x 10 -2, and the corresponding HI is 560. These values estimate that if ground water at the site boundary in the central GSA were to be used for residential purposes on a regular basis for 30 years, there would be an unacceptable incremental excess cancer risk and unacceptable noncancer health effects.

We also evaluated risk and hazard associated with potential residential use of contaminated ground water at the site boundary nearest to the eastern GSA debris burial trenches. The individual excess lifetime cancer risk attributable to the potential use of ground water at this location is 5 x 10 -5, and the corresponding HI is 5 x 10 -1. In addition, we calculated the risk and hazard associated with potential use of contaminated ground water at two offsite locations, wells CDF-1 and SR-1. The individual excess lifetime cancer risks attributable to the potential use of ground water at these locations are 1 x 10 -5 and 2 x 10 -5, respectively. The corresponding HIs are 1.4 X 10 -1 and 1.6 X 10 -1. While the noncancer HI for these scenarios are within acceptable limits (HI <1), the potential excess lifetime cancer risk is within the range (between 10 -4 and 10 -6) where risk management measures are necessary (U.S. EPA, 1990a).

Reference documents for calculations and estimates of potential cancer risk and hazard index

and the results are summarized in Table 6.

2.6.7.4. Uncertainty in the Baseline Public Health Assessment

Uncertainties are associated with all estimates of potential carcinogenic risk and noncarcinogenic hazard. For example, the exposure parameters recommended by the U.S. EPA (1990b; 1991) are typically obtained from the 90th or 95th percentile of a distribution; they are not necessarily representative of an average individual or of average exposure conditions. Consequently, use of multiple upper-bound parameters may contribute to overly conservative estimates of potential exposure, risk, and hazard.

In addition, the total cancer risk and/or total HI was calculated by summing risk of HQs for all contaminants at a given location, where each chemical-specific estimate of risk or hazard represents exposures from multiple pathways. Implicit in the summation of risk and hazard, is the assumption that the effects of exposure to more than one chemical are additive. This simplifying assumption does not consider similarities or differences in target organ toxicity, mechanism(s) of action, or the possibility of synergistic or antagonistic effects of different chemicals in the mixture.

Other uncertainties associated with the estimates of risk and hazard are OU-specific and are related to assumptions made in the modeling conducted to provide exposure-point concentrations, which were subsequently used to calculate risk and hazard. Modeling was conducted to provide estimates of exposure-point concentrations that were used to calculate risk and hazard associated with exposure to contaminated ground water migrating from the central and eastern GSA source areas to potential receptor wells CDF-1, SR-1 and at hypothetical wells at the site boundary as discussed in Section 2.6.3.

The following assumptions were made in the ground water modeling, which may result in uncertainties associated with the risk and hazard estimates:

1. The health conservative assumption was made that the 95% UCL for TCE at the central and eastern GSA source areas will reach the site boundary.

2. Human exposure was assumed to result from potentially contaminated ground water if a hypothetical well were to be installed, at the site boundary in the near future and was used for residential purposes on a regular basis. However, water in this area is not currently used for domestic purposes, and Removal Action remediation activities are currently underway to remove ground water contaminants.

   In addition, the private land directly adjacent to the GSA source areas is open rangeland, and we are not aware of any plans to build homes or install wells there in the near future.

3. The source terms for plume migration in both the central and eastern GSA were assumed to remain constant despite ongoing and planned remediation activities in the GSA. Any change in the source term would result in a direct proportional change in the exposure-point concentration used to calculate risk and hazard.

4. Both the source concentration and volumetric flow rate, which define the source term, were estimated at the high end of their expected range.

5. A dilution factor was applied to well CDF-1 to estimate exposure-point concentrations based on contaminant concentrations detected in different water-bearing zones from which well CDF-1 pumps water. Changes in the dilution factor would cause a direct proportional change in the estimated TCE exposure-point concentration used to calculate risk and hazard.

6. Other assumptions were made to define model parameters such as porosity, ground water velocity, dispersivity ratio, and TCE decay half-life used in modeling. The sensitivity of the predicted maximum exposure-point concentration to these input parameters is discussed in Appendix P-20 of the Site 300 SWRI.

The cumulative excess cancer risk calculated for Building 875 indoor air was based on VOC concentrations from soil samples collected from the vicinity of the Building 875 dry well pad prior to startup of the SVE system. It is likely, due to ongoing soil remediation activities through SVE, that current VOC soil concentrations are lower than what was used to calculate excess cancer risk in the baseline risk assessment. In addition, Building 875 is located approximately 35 ft from the dry well pad source area. Therefore, the soil concentration and resulting soil vapor concentrations under Building 875 are likely to be lower than those used to calculate the inhalation risk inside Building 875.

2.6.8. Summary of the Baseline Ecological Assessment

The baseline ecological assessment, conducted to evaluate the potential for adverse impact to plants and animals from long-term exposure to contaminants in the GSA OU, determined that VOCs do not pose ecological risk in this area. This determination was based on estimates of potential hazard from exposure to contaminants that were calculated for mammal and aquatic species that could potentially inhabit this area, as well as biological surveys conducted to determine which species actually inhabit or migrate through the GSA.

A detailed discussion of the baseline ecological assessment can be found in Section 1.6.4.1 of the GSA FS (Rueth and Berry, 1995).

2.7. Description of Remedial Action Alternatives

The FS for the GSA OU presented three remedial action alternatives to address 1 potential risk posed by ingestion of VOCs in ground water, and 2) potential VOC inhalation risks inside

Building 875. The three remedial action alternatives are summarized in Table 7. It should be noted that the estimated costs for all alternatives presented in this ROD are lower than the

cost estimates presented in the GSA FS and Proposed Plan. This is due to subsequent modifications to the 1) contingency point-of-use treatment component based on negotiations with the well owner, and 2) ground water monitoring component based on changes made to the eastern and central GSA treatment facility monitoring program permit requirements.

2.7.1. Alternative 1-No Action

A no-action alternative is required by CERCLA as a basis from which to develop and evaluate remedial alternatives and is the postulated basis of the baseline risk assessment. Under a no-action response, all current remedial activities in the GSA OU would cease. However, the following activities would be performed:

- Monitoring of VOCs in ground water, reporting, maintenance, database management, and quality assurance/quality control (QA/QC).

- Administrative controls including restricting access to or activities in certain areas of contamination, as necessary.

Modeling indicates that ground water VOC concentrations would be reduced to drinking water standards through natural attenuation and degradation after 75 years under the Alternative 1 scenario. Ground water monitoring would be conducted for the 75-year period plus five years of post-"remediation" monitoring.

The estimated 80-year present-worth cost of Alternative 1 is $3.47 million. Present-worth cost analysis is a method of evaluating total costs (i.e., the cost of each remedial alternative) for projects that vary in duration by discounting all costs to a common base year (1995) to adjust for the time value of money. The present-worth cost represents the amount of money, which if invested in the initial year (1995) of the remedial action and dispersed over the life of the project, would be sufficient to cover all associated costs.

2.7.2. Alternative 2-Exposure Control

The objective of Alternative 2 is to protect human health by preventing human exposure to TCE and other VOCs through ingestion of ground water from existing water-supply wells by reducing VOC concentrations in water from these wells to drinking water standards (MCLs) through POU treatment. Drinking water standards and MCLs are discussed in Section 2.10.1. Hereafter, drinking water standards will be referred to as MCLs throughout this ROD.

Alternative 2 includes:

- Monitoring and administrative control components of Alternative 1.

- Contingency POU treatment for three offsite water-supply wells: CON-1, CDF-1, and SR-1 (Fig. 10).

As with Alternative 1, reduction of VOC concentrations in ground water through natural attenuation and degradation would take approximately 75 years under the Alternative 2 scenario. Ground water monitoring would be conducted for the 75-year period plus five years of post-"remediation" monitoring.

The present-worth cost of Alternative 2 is $3.69 million.

2.7.3. Alternative 3-Source Mass Removal and Ground Water Plume Control

The objectives of Alternative 3 are to provide increased protection of human health and the environment by: 1) reducing VOC concentrations in ground water to MCLs, 2) reducing residual VOC (DNAPL) mass/volume, 3) reducing VOC concentrations in soil vapor to levels protective of ground water, and 4) mitigating VOC inhalation risk inside Building 875. These objectives will be accomplished through VOC mass removal from contaminant source areas and plume migration control.

Alternative 3 includes all the elements of Alternatives 1 and 2 and adds ground water and soil vapor extraction to remove TCE and other VOCs from ground water, soil and rock. Alternative 3 is divided into two scenarios: Alternatives 3a and 3b. Both are the same with respect to the objective and method of subsurface soil/rock remediation, but differ in their ultimate objectives for ground water remediation. Both Alternative 3a and 3b include:

- All elements of Alternatives 1 and 2.
- Soil vapor extraction and treatment in the central GSA dry well source area.
- Ground water extraction and treatment in the central and eastern GSA.

Under both Alternatives 3a and 3b, DOE would continue to operate the existing soil vapor extraction system at the central GSA dry well area to reduce VOC concentrations in soil vapor to levels protective of ground water and to mitigate VOC inhalation risk inside Building 875. Modeling indicates that soil vapor extraction would reduce soil vapor VOC concentrations to the remediation goals within 10 years. The ground water remediation components of Alternatives 3a and 3b are discussed further below.

2.7.3.1 Alternative 3a-Source Mass Removal Restoration of the Regional Aquifer and Ground Water Plume Control

Under Alternative 3a, DOE would expand the existing ground water extraction and treatment system in the central GSA dry well area to prevent migration of VOCs above MCLs into the regional aquifer. In addition, ground water in the eastern GSA debris burial trenches area and the debris burial trench area west of the sewage treatment pond would be extracted and treated to reduce VOC concentrations to MCLs in the alluvial and regional aquifers.

Modeling indicates that TCE concentrations in the shallow aquifer in the central GSA dry well area need to be reduced to 100 µg/L to prevent migration of VOCs above MCLs into the regional aquifer. After the 100 µg/L remediation goal is achieved, ground water extraction would be discontinued and natural attenuation would reduce VOC concentrations in the shallow water bearing zone (Qt-Tnsc 1 hydrogeologic unit) to MCLs.

The existing ground water extraction and treatment system in the eastern GSA debris burial trenches area would continue to operate to reduce VOC concentrations in ground water to MCLs in the shallow and regional aquifers.

Modeling indicates that ground water extraction would reduce ground water VOC concentrations in Building 875 and debris burial trenches areas to MCLs within 30 years and 10 years, respectively. Modeling also indicates that an additional 35 years may be required to reduce VOC concentrations to MCLs in the shallow aquifer in the central GSA through natural attenuation and dispersion. The configuration and operation of both the central and eastern GSA treatment systems would be optimized during remediation to maximize system efficiency. Ground water monitoring would be conducted throughout this 65-year period to achieve MCLs in both the shallow and regional aquifer plus five years of post-remediation monitoring.

The estimated 70-year present-worth cost of Alternative 3a is $17.17 million.

2.7.3.2 Alternative 3b-Source Mass Removal, Restoration of the Shallow and Regional Aquifer and Ground Water Plume Control

Alternative 3b consists of all components of Alternative 3a but continues active ground water extraction and treatment in the central GSA dry well area until MCLs are reached in all affected ground water. Modeling indicates that ground water extraction in the central GSA dry well area would reduce VOC concentrations to current MCLs in 55 years. Ground water monitoring will be conducted throughout the 55 years of remediation, plus five years of post-remediation monitoring.

The estimated 60-year present-worth cost of Alternative 3b is $18.90 million. This estimated cost for Alternative 3b is slightly lower than the estimated cost presented in the GSA FS ($19.75 million) for reasons already discussed in the introduction to Section 2.7.

2.8. Summary of Comparative Analysis of Alternatives

The characteristics of the three alternatives were evaluated against the nine EPA evaluation criteria:

- Overall protection of human health and environment.
- Compliance with ARARs.
- Short-term effectiveness.
- Long-term effectiveness and permanence.
- Reduction of contaminant toxicity, mobility, or volume.
- Implementability.

- Cost effectiveness.
- State acceptance.
- Community acceptance

As specified by EPA, the two most important criteria are adequate protection of public health and the environment and compliance with all Federal and State ARARs. In the following sections and Table 8, Alternatives 1 through 3 are compared against these nine criteria.

Additional details of the evaluation of these remedial alternatives with respect to the EPA evaluation criteria can be found in Chapter 5 of the GSA FS (Rueth and Berry, 1995).

2.8.1. Overall Protection of Human Health and the Environment

- Alternative 1 does not actively remediate contaminated soil or ground water and thus would not protect human health or the environment because the potential beneficial uses of ground water would not be readily restored and the potential risk associated with the inhalation of VOCs above health-based concentrations in Building 875 are not mitigated.
- Alternative 2 protects human health by preventing ingestion of ground water containing VOCs above MCLs. However, because VOCs are not actively remediated, potential beneficial uses of ground water would not be readily restored. As with Alternative 1, this alternative does not prevent potential inhalation of VOCs above health-based concentrations in Building 875.
- Alternative 3a uses exposure control methods and administrative controls to provide initial protection to human health. This alternative would also protect human health by restoring and protecting the beneficial uses of ground water in the Tnbs 1 regional aquifer through active remediation. Alternative 3a protects human health by preventing potential inhalation of VOCs above health-based concentrations in Building 875 by reducing soil vapor VOC concentrations through soil vapor extraction. Alternative 3a would employ ecological surveys and appropriate response actions, if necessary, to protect the environment.
- Alternative 3b uses exposure control methods and administrative controls to provide initial protection to human health. This alternative also protects human health by restoring and protecting the beneficial uses of ground water in both the shallow and Tnbs 1 regional aquifer through active remediation. Alternative 3b protects human health by preventing potential inhalation of VOCs above health-based concentrations in Building 875 by reducing soil vapor VOC concentrations through soil vapor extraction. Alternative 3b employs ecological surveys and appropriate response actions, if

necessary,
to protect the environment.

2.8.2. Compliance with ARARs

A complete discussion of potential ARARs related to the three proposed remedial alternatives is presented in the GSA FS, and summarized in Section 2.10 of this report.

- Alternative 1 meets all ARARs if natural attenuation and dispersion reduce VOC concentrations in ground water to MCLs. If natural attenuation and dispersion do not occur, VOC concentration would remain well above MCLs, which would not meet the requirements of the following ARARs: Safe Drinking Water Act, the Region V Basin Plan, or State Resolutions 68-16 and 92-49.

- Like Alternative 1, Alternative 2 would rely solely on natural attenuation to meet remediation goals, and therefore may not comply with the requirements of the Safe Drinking Water Act, the Region V Basin Plan, and State Resolutions 68-16 and 92-49.

- The goal of Alternative 3a is to use active soil vapor and ground water remediation to meet the requirements of the Safe Drinking Water Act, the Region V Basin Plan, and State Resolutions 68-16 and 92-49 in the Tnbs 1 regional aquifer. This alternative relies,
in part, on natural attenuation and dispersion, and therefore may not meet these ARARs in the alluvial aquifer in the central GSA.

- Alternative 3b would use active soil vapor and ground water remediation to meet all ARARs in both the alluvial and Tnbs 1 regional aquifer.

2.8.3. Short-Term Effectiveness

- Alternative 1 would not remove VOCs from the subsurface. Therefore, this alternative would not be effective in short-term remediation of the site.

- Alternative 2, while preventing human exposure through ingestion of VOCs in ground water from existing water-supply wells, does not address risk to human health from potential exposure to VOC vapors inside Building 875. Because this alternative does not
actively reduce VOC mass, it would not provide short-term remediation of the site.

- Alternative 3a would immediately protect the public from potential exposure pathways. This alternative uses ground water and soil vapor extraction to immediately begin removing VOCs and reducing VOC concentrations in ground water and soil vapor, and would be effective in the short term.

- Like Alternative 3a, Alternative 3b immediately protects the public from potential exposure pathways. This alternative uses ground water and soil vapor extraction to immediately begin removing VOCs and reducing VOC concentrations in ground water and soil vapor.

- All alternatives would be effective in the short term by protecting site workers and the
community during the remedial action by preventing potential exposure through the use

of administrative controls. No adverse environmental impacts are anticipated.

2.8.4. Long-Term Effectiveness and Permanence

- Alternative 1 would not use active measures to reduce VOCs in ground water. It does not address potential risk from ingestion of VOCs in ground water from existing water supply wells or potential inhalation risk inside Building 875. Therefore, this alternative would not be effective in long-term remediation of the site.

- Alternative 2 would provide protection from exposure risk at existing water-supply wells by providing immediate and long-term response if VOCs greater than MCLs reach these wells. However, since this alternative does not reduce VOC mass or address potential inhalation risk inside Building 875, it would not be an effective long-term remedy.

- Alternative 3a would use ground water and soil vapor extraction to permanently reduce VOC concentrations to MCLs in the Tnbs 1 regional aquifer. However, this alternative relies on natural attenuation to reduce VOC concentrations to MCLs in the alluvial aquifer in the central GSA. Because the reliability of natural attenuation to reach MCLs is uncertain, this alternative may not provide an effective long-term remedy. Alternative

3a would permanently reduce VOC soil vapor concentrations to levels protective of ground water and mitigate inhalation risk inside Building 875.

- Alternative 3b would provide an effective long-term remedy by permanently reducing VOCs to MCLs in both the alluvial and Tnbs 1 regional aquifer through active remediation. Alternative 3b will permanently reduce VOC soil vapor concentrations to levels protective of ground water and mitigate inhalation risk inside Building 875.

2.8-5. Reduction of Contaminant Toxicity, Mobility, or Volume

- Alternatives 1 and 2 do not actively remove VOCs from the subsurface. These alternatives are dependent on natural attenuation processes that may not be effective in reducing toxicity, mobility, or volume of the VOCs.

- Soil vapor and ground water extraction in Alternative 3a would significantly reduce the toxicity, mobility, and volume of contaminants in the subsurface through active remediation measures.

- Alternative 3b will significantly reduce the toxicity, mobility, and volume of contaminants in the subsurface through active ground water and soil vapor remediation.

2.8.6. Implementability

- Alternative 1 could be easily implemented by utilizing the existing ground water monitoring program.

- Alternative 2 could be implemented using the existing ground water monitoring program and readily available services and materials for POU treatment system construction and operation.

- Alternative 3a could be easily implemented utilizing soil vapor and ground water extraction and treatment systems which are currently in place, permitted, and operating in the GSA. Modifications to these systems proposed in Alternative 3a are readily implementable.

- Alternative 3b could be easily implemented utilizing soil vapor and ground water extraction and treatment systems which are currently in place, permitted, and operating in the GSA. Modifications to these systems proposed in Alternative 3b are readily implementable.

2.8.7. Cost Effectiveness

The cost estimates prepared for the remedial alternatives, as well as the assumptions made in preparing these estimates, are described in detail in Appendix F of the GSA FS. The cost estimates may change as the result of modifications during the remedial design and construction process. Any revisions to the cost estimates will be presented in the Remedial Design Document.

- The estimated present-worth cost of Alternative 1 is $3.47 million for up to 80 years of ground water monitoring. This alternative has the lowest cost because it does not include active remedial actions.

- The estimated present-worth cost of Alternative 2 is $3.69 million. This includes up to 80 years of ground water monitoring and contingency POU treatment at existing water supply wells, if necessary. Alternative 2 has a higher cost because it includes capital construction projects (construction and installation of POU treatment systems) and ground water monitoring, but no active remediation by long-term extraction and treatment.

- The estimated present-worth cost of Alternative 3a is $17.17 million. This includes up to 10 years of SVE, ground water extraction for up to 10 years in the eastern GSA and 30 years in the central GSA, and up to 70 years of ground water monitoring. The higher cost of Alternative 3a is due to capital construction projects, extraction and treatment

system modifications, installation of additional extraction wells and piezometers, as well as long-term extraction and treatment system operation and maintenance and ground water monitoring. The costs incurred to implement Alternative 3a are associated with the active remediation of soil and ground water in the GSA. Remediation would continue until VOC concentrations in ground water are reduced to MCLs in: 1) the Tnbs 1 regional aquifer in the central GSA, and 2) the alluvial aquifer and the Tnbs 1 regional aquifer in the eastern GSA. Also, VOC concentrations in soil vapor will be reduced to levels protective of ground water and to mitigate inhalation risk inside Building 875.

- The estimated present-worth cost of Alternative 3b is $18.90 million. This includes up to 10 years of SVE, ground water extraction for up to 10 years in the eastern GSA and 55 years in the central GSA, and up to 60 years of ground water monitoring. This alternative has the highest present-worth cost because it includes all the costs of Alternative 3a but operates the central GSA ground water extraction system for an additional 25 years. As with Alternative 3a, the costs incurred to implement Alternative 3b are associated with the active remediation of soil and ground water in the GSA. However, the cost of Alternative 3b is higher due to the continued remediation of ground water to reduce VOC concentrations to MCLs in both the alluvial and Tnbs 1 regional aquifers. The cost difference between Alternative 3a and 3b represents the additional cost of remediating ground water in the Qt-Tnsc 1 aquifer in the central GSA to reduce VOC concentrations to MCLs.

2.8.8. State Acceptance

The State regulatory agencies, DTSC, and CVRWQCB have provided ARARs for the site, reviewed and evaluated the remedial technologies and alternatives, participated in the selection of the final remedy, and provided oversight and enforcement of State environmental regulations.

The DTSC and the CVRWQCB concur with the U.S. EPA and DOE that Alternative 3b provides the best balance of trade-offs with respect to the evaluation criteria.

2.8.9. Community Acceptance

The regulatory agencies have monitored and reviewed public acceptance of the final selected remedy. Public comments concerning each alternative and the selected remedy have been considered and used, as appropriate, in the preparation of this ROD. All public comments on the

Proposed Plan, and selected remedy for the GSA are addressed in the Responsiveness Summary section of this document.

2.9. Selected Remedy

DOE, U.S. EPA, CVRWQCB, and DTSC agree that Alternative 3b is the most appropriate remedial alternative, considering the CERCLA evaluation criteria. Under Alternative 3b, DOE will continue subsurface remediation using ground water extraction coupled with SVE to reduce potential risk and contaminant mass. Throughout the remediation process, other more innovative remediation technologies will be considered to enhance VOC mass removal and treatment of extracted soil vapor and/or ground water. In situ innovative technologies for VOC remediation will also be considered.

This discussion of the selected remedy includes cleanup goals for the media of concern, details of the remedy components, extraction and treatment system design and operation, performance evaluations, consideration of innovative technologies, reporting, and a summary of preliminary cost estimates.

2.9.1. Cleanup Goals

The objectives of the selected remedial alternative are to: 1) reduce VOC concentrations in ground water to levels protective of human health and the environment, 2) reduce VOC concentrations in soil vapor to meet ground water cleanup goals, and 3) mitigate VOC inhalation risk inside Building 875.

Objectives 1 and 2 will be accomplished by ground water extraction and treatment to reduce VOC concentrations to MCLs, supplemented with soil vapor extraction and treatment to reduce soil vapor concentrations to meet ground water cleanup goals. Objective 3 will be accomplished with the existing SVE system used to accomplish objectives 1 and 2. Soil vapor concentrations protective of ground water are significantly lower than concentrations required to reduce inhalation risk inside Building 875.

2.9.1.1. Ground Water Cleanup Goals

The cleanup goal for ground water is to reduce VOC concentrations to MCLs in all impacted ground water in the GSA. The current MCLs for the VOC contaminants of concern in ground water in the GSA are presented in Table 9. Ground water monitoring will be conducted as discussed in Sections 2.9.2.1 and 2.9.3.1 to determine when MCLs for the contaminants of concern have been achieved in ground water.

2.9.1.2. Soil Vapor Cleanup Goals

Protection of Ground Water

One objective of SVE at the Building 875 dry well pad is to reduce VOC mass and concentrations to meet ground water cleanup goals. The VOCs in the vadose zone will be remediated to the extent technically and economically feasible to minimize further degradation of the ground water by the contaminants in the vadose zone. It is generally preferable from a technical and cost perspective to cleanup contamination in the vadose zone before it reaches the ground water. The vadose zone cleanup will be achieved when it is demonstrated that:

1) The remaining vadose zone VOC contaminants no longer cause concentrations in the leachate to exceed the aquifer cleanup levels, based on an interpretation of soil vapor data using an appropriate vadose zone model. Leachate is the mobile portion of water in the vadose zone containing soluble constituents that has been leached from the soil in the vadose zone. Aquifer cleanup levels have been established as MCLs as defined in applicable Federal and State safe drinking water standards; and

2) VOCs have been removed to the extent technically and economically feasible in order to meet the aquifer cleanup levels sooner, more cost-effectively, and more reliably.

The SVE system will be operated until the demonstration is made that Items 1 and 2 above have been met, unless the parties consent to the use of an alternate technology for the purpose of meeting the requirements outlined in Items 1 and 2 above. DOE, U.S. EPA, DTSC, and the CVRWQCB agree to evaluate the performance of the SVE system, as well as to determine when vadose zone cleanup has been achieved based on the technical criteria discussed in Section 2.9.3.2.

Risk Reduction within Building 875

The SWRI baseline risk assessment indicated that the cumulative potential excess cancer risk from inhalation of indoor air within Building 875 was 10 -5. This calculation was based on VOC concentrations from soil samples collected in the vicinity of the Building 875 dry well pad prior to the July 1994 startup of the SVE system. It is likely, due to nearly two years of ongoing SVE soil remediation, that current VOC soil concentrations are lower than what was used to calculate this excess cancer risk in the baseline risk assessment. Soil vapor concentrations protective of ground water are significantly lower than concentrations that will be required to reduce potential inhalation risk inside Building 875. DOE will conduct soil vapor monitoring, as discussed in Section 2.9.3.2, and use these data to validate reduction of potential inhalation risk inside Building 875.

2.9.2. Treatment System Design

The majority of the remediation components are readily implementable with minor modifications to the existing soil vapor and ground water extraction and treatment systems at the GSA OU.

The major components of the selected remedy (Alternative 3b) include:

- Ground water monitoring throughout the predicted 55 years of remediation plus five years of post-remediation monitoring.
- Administrative controls including access restrictions and procedures for construction in areas where possible exposure to contaminated media may occur.
- Contingency POU treatment for offsite water-supply wells.
- Soil vapor extraction and treatment in the central GSA dry well source area.
- Extraction and treatment of ground water in the central and eastern GSA.

The design, operational, and/or implementation details of these components are discussed in detail in the following sections.

2.9.2.1. Monitoring and Administrative Controls

Monitoring

Currently, the preliminary ground water monitoring program for the selected remedy (Alternative 3b) consists of sampling 7 wells quarterly, 89 wells semiannually, and 12 wells annually for the first 10 years. Between years 11 and 55, after the eastern GSA ground water extraction system and two of the central GSA extraction wells have been turned off, sampling frequency will be reduced to semiannually for 39 wells, and annually for 50 wells. After 55 years, when ground water fate and transport modeling predicts that VOC concentrations in ground water have been reduced to MCLs and the central GSA ground water extraction system can be turned off, ground water sampling will be reduced further to semiannually for 37 wells and annually for 37 wells for the five years of post-remediation monitoring. Samples will be analyzed for VOCs by EPA Method 601, and some wells in the central GSA would also be analyzed for fuel hydrocarbons by EPA Method 602. If remediation does not show that cleanup is proceeding as the modeling predicts, remediation methods will be revisited.

Consistent with the NCP, the ground water data obtained as part of the monitoring program will be reviewed at least every five years. If these data indicate that VOC concentrations, ground water flow direction, and/or velocity have changed and significantly affect the cleanup, the monitoring program would be re-evaluated.

Soil vapor concentrations will be monitored periodically from the seven extraction wells during the predicted 10 years of SVE to evaluate remediation progress and provide data for system optimization. VOC concentrations in soil vapor samples can be used to determine if there is preferential VOC removal from certain SVE wells. This information will be used to vary the extraction configuration to optimize VOC mass removal from soil vapor; i.e., extract from wells with higher VOC soil vapor concentrations while using wells with lower VOC concentrations as air inlet wells. The configuration and operation of the SVE system will be optimized during remediation to maximize system efficiency.

In addition, existing soil vapor monitoring points in the vicinity of Building 875 will be monitored for TCE and PCE. The TCE and PCE concentrations will be used to periodically evaluate the effectiveness of SVE in mitigating inhalation risk inside Building 875.

Although the inhalation risk inside Building 875 was calculated by adding the individual lifetime cancer risk for a total of six VOCs, the sum of the individual cancer risks for TCE and PCE (1.11 X 10 -5) constitutes the largest portion of the total additive inhalation cancer risk inside Building 875 (1.17 X 10 -5). For this reason, TCE and PCE will be used as the indicator VOCs for periodically assessing additive inhalation cancer risk inside Building 875. Once the additive inhalation risk reaches acceptable levels for TCE and PCE, soil vapor samples will be collected and analyzed for all six VOCs originally used to calculate inhalation risk inside Building 875 in the SWRI. These data will then be used as direct input parameters to the models that were used to calculate inhalation risk in the SWRI to calculate a total additive inhalation cancer risk inside Building 875.

Soil vapor monitoring will be discussed in detail in the remedial design document.

Specific details of the ground water and soil vapor monitoring network will be presented in the Remedial Design document.

Additionally, surface water from springs 1, 2, and GEOCRK will be sampled and analyzed for VOCs, drinking water metals, general minerals, high explosives, tritium, and gross alpha and beta as part of ongoing site-wide program of ecological studies. The current program of conducting ecological resource surveys for sensitive species prior to the initiation of any ground-disturbing activities will also continue. The need for detailed ecological resource surveys will be evaluated every five years as part of the contract renewal negotiations between the University of California and DOE.

Administrative Controls

The following administrative controls are a component of the selected remedy and are either currently in effect or easily implementable. Because DOE intends to retain stewardship of Site 300 for the foreseeable future, existing security patrols, site access restrictions, and fencing along the entire perimeter of Site 300 will be maintained. These restrictions will prevent public access, and thus potential exposure, to the source areas and areas of highest ground water VOC concentrations. Additionally, DOE will continue to consider site conditions (especially in the

vicinity of vadose zone contamination) prior to implementing construction of any facility to prevent potential worker exposure to subsurface contaminants.

2.9.2.2. Contingency Point-of-Use Treatment

POU treatment systems will be installed at offsite water-supply wells CON-1, CDF-1 and SR-1 (Fig. 10) if VOCs in these wells are at or above MCLs. As part of the monitoring plan, water-supply wells CON-1 and CDF-1 will be monitored for VOCs monthly. Guard wells W-25D-01, W-25D-02, and W-24P-03, located the farthest downgradient from the source and upgradient from water-supply well SR-1, will also be monitored for VOCs. Well W-24P-03 will be monitored quarterly, and wells W-2513-01 and -02 monitored semiannual. If VOCs are detected in well W-24P-03, the monitoring frequency of this well will be increased to monthly, and wells W-25D-01 and -02 monitored quarterly. Should VOCs be detected in well W-24P-03,

provisions will be made to routinely sample well SR-1. In the event that VOCs at or above MCLs are detected and confirmed in wells CDF-1, CON-1, or SR-1, implementation of POU treatment at that well will be discussed with the regulatory agencies and well owner(s).

Wells CDF-1 and CON-1 are located approximately 100 and 200 ft, respectively, from the Site 300 GSA boundary. Due to the close proximity of these wells to the VOC plume, DOE currently has a POU contingency plan in place for these wells in a Memorandum of Understanding that has been reviewed and approved by the well owner.

Well SR-1 is located approximately 1.5 miles downgradient from guard well W-24P-03. No VOCs have ever been detected in ground water collected from W-24P-03, the furthest downgradient well. In addition, the VOC plume has been receding upgradient back toward Site 300 as result of remediation efforts and is currently over 2 miles from well SR-1. However, if VOCs were detected in guard well W-24P-03, the property owner would be contacted to set up a contingency plan similar to that established for wells CON-1 and CDF-1.

The conceptual POU treatment system design consists of a gravity-flow aqueous-phase GAC treatment system utilizing two GAC canisters connected in series and mounted on a double-containment skid. Sampling ports will be provided between the canisters, as well as at the inlet and exit pipes. Other equivalent treatment technologies may be considered, if appropriate.

In the event that POU treatment becomes necessary, DOE will develop and submit a plan for regulatory approval to permanently remedy the affected water supply.

2.9.2.3. Soil Vapor Extraction and Treatment

SVE will be used as the primary remedial technology to: 1) reduce vadose zone contamination, including potential DNAPLs in unsaturated bedrock, to concentrations protective of ground water, and 2) reduce potential inhalation risk inside Building 875. Most vadose zone contamination is found in the immediate vicinity of the Building 875 dry well pad, so SVE efforts will be focused in that area.

Residual DNAPLs may be in the vadose zone and dewatered bedrock in the vicinity of the

Building 875 dry well pad. The dewatered zone consists of bedrock that was formerly saturated prior to the initiation of ground water extraction activities in the central GSA, but is now unsaturated or dry due to pumping. SVE and treatment would also address residual DNAPLs. SVE has been identified as a technology that can effectively remediate volatile DNAPLs in the unsaturated zone and prevent uncontrolled migration of VOCs in soil gas (U.S. EPA, 1992d; 1993b). In addition, when SVE is coupled with lowering of the water table through ground water extraction, residual DNAPLs can be removed from the area below the original water table elevation (U.S. EPA, 1992d).

In July 1994, soil vapor extraction and treatment activities were initiated in the central GSA Building 875 dry well pad area. The current SVE system uses seven extraction wells and treats the vapor with two 140-lb vapor-phase GAC canisters connected in series prior to discharge to the atmosphere. The locations of the SVE wells are shown in Figure 11. VOC concentrations in the SVE-combined influent stream have decreased from a high of 450 ppm v/v in July 1994 to current concentrations of 5 ppm v/v or below in the second quarter 1996. Similarly, VOC concentrations in soil vapor samples from the individual SVE wells have decreased from a

maximum concentration of 600 ppm v/v in well W-71 at system startup to a maximum of 33 ppm v/v in well W-875-07 in the second quarter 1996. As of second quarter 1996, 27,238 grams of VOCs have been removed in the central GSA through SVE.

Soil vapor is currently extracted at rate of approximately 20 standard cubic ft per minute. Based on field observations, we estimate that the current system adequately captures the soil vapor plume in the Building 875 dry well pad source area and that no additional SVE wells are necessary. The necessity of performing SVE at other locations in the GSA OU will be evaluated as remediation progresses. Other equivalent soil vapor treatment technologies may be considered, if appropriate.

The seven SVE wells are also used for ground water extraction and are successfully maintaining a dewatered zone in the immediate vicinity of the Building 875 dry well pad. Dewatering has exposed more soil/rock to the applied vacuum of SVE, thereby significantly enhancing VOC mass removal. This dewatered zone will continue to be maintained while SVE is operating.

The central GSA treatment is a dual soil vapor and ground water extraction and treatment system, and both systems will initially be operated simultaneously. Upon reaching conditions presented in Section 2.9.3.2, the soil vapor system will be shut down and only the ground water extraction and treatment system will operate. Should site conditions change or ground water monitoring indicate that soil vapor concentrations have rebounded and will cause ground water to exceed ground water cleanup goals, the soil vapor system will be restarted and operated as appropriate until such conditions cease. DOE agrees to operate the dual soil vapor and ground water extraction and treatment system to reduce ground water VOC concentrations to meet ground water cleanup goals in the most efficient manner.

During preparation of the remedial design report and throughout the life of the project, DOE

may conduct more extensive testing to determine the effective vacuum influence and to optimize performance. Optimization may include expanding the SVE system with additional existing wells to increase the area of influence, and/or implementing cyclic operation (e.g., alternating periods when the system is on and off) to maximize the rate of VOC mass removal.

2.9.2.4. Ground Water Extraction and Treatment

Eastern GSA

As shown in Figure 8, ground water concentrations exceed MCLs in the eastern GSA in the vicinity of the former debris burial trench area, east of the sewage treatment pond. Ground water extraction and treatment in this area is designed to reduce ground water VOC concentrations to MCLs.

The eastern GSA ground water extraction system has been operating since July 1991, and currently consists of three extraction wells pumping a total of up to 46 gal per minute (gpm). As of second quarter 1996, over 76 million gal of ground water have been extracted and treated in the eastern GSA ground water treatment system with 4,417 grams of VOCs removed from ground water.

Data collected through fourth quarter 1995 indicate that TCE concentrations have been generally decreasing in all eastern GSA alluvial wells since 1992. There was an average TCE concentration decrease of 75% in eastern GSA alluvial wells between the historical maximum concentration and the concentration in third quarter 1994. The maximum observed TCE concentration in eastern GSA alluvial wells in fourth quarter 1995 was 18 µg/L in well W-26R-01, a significant decrease from the historical maximum concentration of 74 µg/L TCE in well W-26R-03 in January 1992.

The 1 µg/L isoconcentration contour for the ground water VOC plume in the eastern GSA previously extended 4,750 ft downgradient from the debris trench area and the 5 µg/L isoconcentration contour extended 4,625 ft downgradient based on fourth quarter 1991 (SWRI) data (Fig. 12). Fourth quarter 1995 data indicate that the 1 µg/L isoconcentration contour for the ground water VOC plume now extends only 1,950 ft downgradient from the debris burial trench area, while the 5 µg/L isoconcentration contour extends only 600 ft downgradient (Fig. 8). Remediation efforts in the eastern GSA are thought to be at least partially attributable to this decrease in plume length.

VOC concentrations in the regional aquifer in the eastern GSA have also been significantly decreasing as a result of existing alluvial ground water remediation. TCE concentrations have decreased in ground water in the Tnbs 1 regional aquifer from a maximum of 71 µg/L in third quarter 1992, to a maximum of 19.2 µg/L in fourth quarter 1995 as shown in Figures 13 and 9, respectively. In this area, the alluvium and underlying regional aquifer are hydraulically connected, and contamination in the regional aquifer is a result of downward vertical

migration of contaminants from the alluvial aquifer. An extraction well in the regional aquifer in the debris burial trench area was not considered due to concerns that pumping the regional aquifer would accelerate/facilitate downward vertical contaminant migration from the overlying source in the alluvium into the Tnbs 1. If remediation of the alluvial aquifer does not appear effective in removing VOCs from ground water in the regional aquifer in the future, direct remediation of the regional aquifer in the eastern GSA will be considered.

Based on modeling and field data associated with the existing extraction system, the extraction well configuration shown in Figure 11 sufficiently captures the plume in the eastern GSA to meet remediation goals. The portion of the plume downgradient of the eastern GSA extraction wells that is not being actively captured has been retreating since ground water extraction was initiated. We anticipate this trend will continue. Therefore, no additional wells are necessary at this time. The effectiveness of this system is discussed in Section 1.4.8.2 of the GSA FS.

Ground water modeling predicts that the eastern GSA ground water extraction and treatment system will remediate ground water to MCLs in five years. However, we have conservatively assumed that this system will need to operate for ten years.

In the GSA FS, a low-profile shallow-tray air stripper was the chosen treatment system for ground water in the eastern GSA. Aqueous-phase GAC was not a selected technology in the FS due to concerns regarding possible biofouling and clogging that might require premature GAC replacement, and thereby reduce system efficiency. The FS also stated that aqueous-phase GAC treatment was being further evaluated as a component of the final system design. Since issuing the GSA FS in October 1995, aqueous-phase GAC was evaluated for ground water treatment in the eastern GSA. This evaluation consisted of:

1. Reviewing ground water chemistry data from eastern GSA extraction wells to evaluate the potential for carbonate clogging or bacterial biofouling of the GAC system.

2. Performing a system test by connecting two aqueous-phase GAC units to the eastern GSA treatment system to monitor the effectiveness of GAC in reducing VOCs, and to identify potential problems such as biofouling and clogging.

Two aqueous-phase GAC units were connected in series prior to the air sparging tank. Water from the eastern GSA extraction wells passed through sediment filters and then went directly into the GAC units. The GAC units were sampled and monitored to ensure VOCs were effectively removed to the NPDES permit required levels, and to evaluate the potential effects of biofouling and carbonate clogging on GAC system efficiency. Following treatment in the GAC units, the water passed through the air sparging tank. The GAC units were evaluated in this manner for eight months, from December 1995 to August 1996. The results of this evaluation

indicated that: 1) the aqueous-phase GAC units effectively removed VOCs from ground water to NPDES permit levels (<0.5 µg/L), and 2) there is no evidence of system efficiency reduction or premature replacement of GAC due to biofouling and clogging of the GAC units.

As discussed in Section 3.3.5.1.1 of the GSA FS, aqueous-phase GAC adsorption is a well established and effective technology for treating chlorinated solvents in ground water. Activated carbon removes contaminants from water by adsorbing them onto its surface. A GAC adsorption system consists of a packed column with an internal plumbing system to distribute the water evenly through the carbon bed. Organic compounds adsorb onto the surface of the GAC as the water flows through the fixed bed.

Aqueous-phase GAC treatment is generally considered to be most effective for low-flow and low-concentration applications. Influent TCE concentrations to the eastern GSA treatment system have steadily declined from a high of 63 µg/L in September of 1991 to an average of 8.2 µg/L for the last four quarters (3rd quarter 1995 to 2nd quarter 1996) and continue to decline. The GAC technology was demonstrated to be effective in treating the eastern GSA ground water at these low concentrations.

Aqueous-phase GAC adsorption is a one-step treatment process as opposed to two-step treatment necessary with air stripping where VOCs are removed from water and are then driven into the vapor phase. Following air stripping, the VOC-laden vapors are treated in vapor-phase GAC units. The aqueous-phase GAC technology, which is inherently less complex in both design and operation than air stripping technology, will incur lower operation and maintenance costs over the long term.

The aqueous-phase GAC technology was evaluated in the eastern GSA and was determined to be:

1. Effective in removing VOCs from ground water to NPDES permit levels (<0.5 µg/L),

2. Capable of treating water to meet all other NPDES permit discharge limits; i.e., pH and total dissolved solids, and

3. More cost effective for long-term operation and maintenance.

As a result, aqueous-phase GAC has replaced air stripping as the preferred technology for the treatment of ground water in the eastern GSA.

Extracted ground water will continue to be treated by two to three aqueous-phase GAC units connected in series (Fig. 14). Other equivalent ground water treatment technologies may be considered in the future, if appropriate. The system has a treatment flow rate capacity of 50 gpm. Ground water is treated to reduce VOC concentrations to the National Pollutant Discharge Elimination System (NPDES) permit requirements of 0.5 µg/L total VOCs. Treated water will continue to be discharged by gravity flow to Corral Hollow Creek about 750 ft to

the
south. Discharged treated water will continue to be monitored to ensure compliance with NPDES permit requirements issued by the CVRWQCB.

A portion of the treated water from the eastern GSA treatment facility may occasionally be discharged to sewage treatment pond to the west as makeup water. During the hot, dry summer months, approximately 1,000 to 1,500 gal of makeup water is added to the sewage treatment pond to compensate for evaporation, which is necessary to keep the sewage treatment pond operating efficiently. It is currently being proposed that treated water from either the eastern or
central GSA treatment facilities be used as this makeup water. In the event that treated water
from the eastern GSA treatment facility is diverted to the sewage treatment pond as makeup water, this will have little overall impact on ground water or Corral Hollow Creek as this treatment facility typically discharges over 40,000 gal a month. Due to the low volume of makeup water required by the sewage treatment pond, and the limited time frame when makeup water is required (summer months only), the majority of the treated water from the eastern GSA
treatment facility would continue to be discharged to Corral Hollow Creek, providing recharge to
the underlying aquifer.

Central GSA

As shown in Figure 6, most VOCs in the GSA OU subsurface are in the central GSA, primarily in the vicinity of the Building 875 dry well pad. While VOC concentrations in ground
water are above MCLs in the Tnbs 1 regional aquifer west of the sewage treatment pond (Fig. 7),
the highest ground water VOC concentrations are in the upgradient overlying alluvial aquifer (Fig. 6) at the Building 875 dry well pad. Ground water extraction and treatment in this area is
designed to reduce ground water VOC concentrations to MCLs in both the alluvial and Tnbs l regional aquifer.

Since April 1993, a ground water treatment system has been in operation in the central GSA at the former Building 875 dry well pad area as part of a CERCLA Removal Action. Currently, the central GSA ground water extraction system pumps a total of approximately 0.3 gpm from seven extraction wells located in the vicinity of the Building 875 dry well pad (Fig. 11). This
very low flow rate is a result of the successful dewatering of the area. As of second quarter 1996, over 568,000 gal of ground water have been extracted and treated in the central GSA ground water treatment system and 3,932 grams of VOCs removed from ground water. A comparison of VOC ground water data collected from Qt-Tnsc l wells during the third quarter 1994 to the historical maximum observed concentrations indicates an overall decrease in VOC concentrations. Specifically, the maximum observed TCE concentration for all Qt-Tnsc 1 wells in samples collected in the third quarter of 1994 was 10,000 µg/L, representing a decrease from
the historical maximum observed concentration of 240,000 µg/L in a bailed ground water sample collected from well W-875-07 in March 1992 (Fig. 15). Third quarter 1994 analytical data suggest that ground water samples collected from the Building 875 dry well pad wells do not

contain TCE at concentration indicative of the presence of DNAPLs in the saturated zone. However, the residual DNAPLs may be present in soil in the dewatered zone and/or vadose zone. The drop in TCE concentrations is thought to be attributable to ground water and soil vapor extraction and treatment efforts ongoing in the central GSA. We have been unable to collect ground water samples from the dry well pad wells since third quarter 1994 because these wells have been effectively dried out preventing ground water sample collection.

Historically, TCE has been detected in ground water samples from monitor wells located west of the sewage treatment pond, which are completed in the Tnbs 1 regional aquifer (Fig. 16). Data indicates that VOC contaminants are in the regional aquifer in the central GSA only where the regional aquifer directly underlies contaminated portions of the alluvial aquifer, such as the area immediately west of the sewage treatment pond. Where present, the Tnsc 1 confining layer acts as a competent confining layer in the vicinity of Building 875 and the areas to the west, preventing TCE migration from the shallow Qt-Tnsc 1 aquifer into the underlying Tnbs 1 regional aquifer.

Data indicate that TCE concentrations have generally been decreasing in all Tnbs 1 monitor wells in the central GSA since 1990. The measured decrease in TCE concentrations may be attributable to the sealing and abandonment of wells 7 and 19 (Fig. 16) in 1988 and 1989. Prior to sealing and abandonment, these wells pumped up to 200 gpm and may have reversed the natural hydraulic gradient, thus causing TCE to migrate into the Tnbs 1 from the overlying alluvium. When pumping ceased from wells 7 and 19, the pre-pumping hydraulic gradient appears to have been re-established in the Tnbs l and, as a result, the TCE concentration in the bedrock aquifer have decreased.

In addition to the seven existing ground water extraction wells, six existing monitor wells (W-7F, W-70, W-872-02, W-7P, W-873-06, and W-873-07) will be converted to ground water extraction wells. Additionally, one new ground water extraction well, W-7Q, will be installed. The purposes of these new ground water extraction wells are to maximize contaminant mass removal in source areas and prevent plume migration in both the alluvial and Tnbsl regional aquifer. Extraction from these new ground water extraction wells will increase the total central GSA flow rate from the current 0.3 gpm to approximately 15 gpm.

Ground water monitor well W-7P will be converted to an extraction well to reduce VOC concentrations in the Tnbs 1 regional aquifer west of the sewage treatment pond. However, extraction from this well may not be initiated until alluvial aquifers extraction stabilizes capture zones and further reduces contamination in the alluvial aquifer.

In conjunction with source area ground water extraction described above, ground water will be extracted from three new extraction wells (W-7R, W-7S, and W-7T) to be installed in the alluvial aquifer about 150 ft west of the sewage treatment pond (Fig. 11). These three extraction wells will capture VOCs not captured by the source area extraction wells, and prevent VOCs from migrating into the Tnbs 1 regional aquifer. Ground water extraction from these three wells will likely continue until ground water extraction in the source areas is discontinued.

Modeling predicts that ground water extraction in the central GSA will likely be required for

55 years to reduce VOC concentrations to current MCLs. Extraction from wells W-873-06 and W-873-07 will be discontinued after 10 years if VOC concentrations in the alluvial aquifer in these source areas has reached MCLs, as modeling predicts.

Ground water extracted in the central GSA will be treated using the existing treatment system with upgrades including replacement of the existing air sparging tanks with a low-profile tray air stripper, aqueous-phase granular activated carbon (GAC), or other equivalent technologies to increase VOC removal efficiency and reduce electrical costs (Fig. 17).

Ground water treatment will continue to reduce VOC concentrations to meet the Substantive Requirement of 0.5 µg/L total VOCs. Treated water will continue to be discharged to a remote canyon in the eastern GSA where the water rapidly infiltrates into the sandstone bedrock. Discharged treated water will be monitored to ensure compliance with Substantive Requirements issued by the CVRWQCB. A portion of the treated water from the central GSA treatment facility may occasionally be discharged to the sewage treatment pond to the east as makeup water during the summer months. In the event that treated water from the central GSA treatment facility is diverted to the sewage treatment pond as makeup water, the overall impact on ground water would be minimal as this treatment facility typically discharges 15,000 to 25,000 gal a month to the canyon in the eastern GSA Due to the low volume of makeup water required by the sewage treatment pond, and the limited time frame when makeup water is required (summer months only), the majority of the treated water from the central GSA treatment facility would continue to be discharged to the eastern GSA canyon, providing recharge to the underlying aquifer.

Once ground water extraction from Tnbs 1 well W-7P is initiated, treated ground water will also be reinjected into well W-7C, screened downdip of W-7P (Fig. 11). Reinjection will enhance natural contaminant flushing toward extraction well W-7P and expedite remediation of the Tnbs 1 regional aquifer. Hydraulic testing will be performed prior to reinjection to ensure that reinjection will not adversely affect rernediation effectiveness or accelerate plume migration. In addition to hydraulic testing and prior to reinjection, treated ground water will be analyzed to verify removal of VOCs to discharge requirements (<0.5 µg/L total VOCs). Analyses will also ensure that concentrations of inorganic compounds do not exceed levels found in water extracted from the Tnbs 1 regional aquifer.

If air stripping is selected as the treatment technology, the vapor stream from the air stripper will be treated by two vapor-phase GAC canisters connected in series and discharged to the atmosphere. The treated vapor stream will be monitored to ensure compliance with the San Joaquin Valley Unified Air Pollution Control District permit requirements. If aqueous-phase GAC is selected as the remedial technology, no vapor stream will exist, therefore air discharge permits will not be necessary.

The exact number and location of ground water extraction wells will be presented in subsequent design documents. Similarly, the choice of treatment technologies will be

evaluated on an ongoing basis to implement the most cost-effective technology that meets all performance criteria.

2.9.3. Performance Evaluations

Ground water and soil vapor monitoring will be conducted throughout the life of the GSA OU remediation project to evaluate the performance and effectiveness of the treatment systems in meeting remediation goals.

2.9.3. 1. Ground Water Remediation

Ground water monitoring, as described in Section 2.9.2.1 will be conducted to evaluate the effectiveness of ground water remediation in reducing VOC concentrations to MCLs in the shallow aquifer and Tnbs 1 regional aquifer. Details of the ground water monitoring network will be presented in the Remedial Design document.

In addition, several new piezometers will be installed for measuring water levels near the extraction Wells to help evaluate ground water capture and remediation effectiveness. Locations of these piezometers will be determined after ground water extraction begins in order to optimize piezometer placement, and will be discussed in the Remedial Design report.

When VOC concentrations in ground water have been reduced to cleanup goals (MCLs), the ground water extraction and treatment system(s) will be shut off and placed on standby. Modeling indicates that VOC concentrations in ground water in the eastern GSA should be reduced to MCLs within 10 years following the initiation of rernediation and within 55 years in the central GSA. Ground water in the GSA will continue to be monitored for a period of five years following shutdown of the system(s). Should VOC concentrations in ground water "rebound" or increase above cleanup goals, reinitiation of remediation efforts will be discussed with the regulatory agencies. If remediation does not show that cleanup is proceeding as modeling predicts, remediation methods will be revisited.

As presented in the National Research Council report (NRC, 1994), the ability of restoring ground water to MCLs using active pumping is unlikely at most sites. If, at some later date, DOE, U.S. EPA, CVRWQCB, and DTSC determine that it is technically and economically infeasible to reduce VOCs in ground water to the cleanup levels established in this ROD, after all reasonable efforts have been made, these parties may re-evaluate the need to achieve these goals.

Throughout the remediation process, innovative remediation technologies will be considered to enhance VOC mass removal and treatment of ground water, as discussed in Section 2.9.4.

2.9.3.2. Soil Vapor Remediation

The primary objectives of soil vapor remediation at the central GSA are to: 1) reduce vadose zone contamination to concentrations to meet ground water cleanup goals, and 2) reduce potential inhalation risk inside Building 875. Because the second objective will likely be achieved long before achieving the first objective, the performance evaluation of the central GSA SVE system will focus on ground water protection, in accordance with ARARs, State Water Resources Control Board Resolution 92-49, and the Region V Basin Plan.

To monitor the progress of subsurface soil remediation , soil vapor concentrations will be monitored at dedicated soil vapor sampling points and at SVE wells through the life of the SVE remediation. In addition, DOE/LLNL will evaluate SVE remediation effectiveness by tracking the cumulative mass of VOCs removed from the Building 875 dry well pad area. The mass of VOCs removed from soil vapor will be plotted as a function of time to determine when the cumulative mass removed approaches asymptotic levels.

As part of the selected remedy, VOC concentrations in soil vapor will be monitored utilizing soil vapor sampling points to ensure that the inhalation risk inside Building 875 is adequately managed. Should existing dedicated soil vapor monitoring points in the vicinity of Building 875

prove insufficient to demonstrate the effectiveness of soil vapor extraction in mitigating the potential inhalation risk in Building 875, additional soil vapor monitoring points will be considered.

The demonstration that the vadose zone cleanup has been achieved to the point where the remaining vadose zone VOC contaminants no longer cause concentrations in the leachate to exceed the aquifer cleanup levels will be made through contaminant fate and transport modeling, trend analysis, mass balance, and/or other means. This demonstration will include examination of the current effects of remaining vadose zone contamination on the ground water, using an appropriate vadose zone model, if necessary. In the case that it is demonstrated that the soil vapor concentration for TCE has reached 360 parts per billion (ppb) on a volume-to-volume basis (and similarly derived concentrations for other VOCs) in the vadose zone, the parties agree that the demonstration has been made that the remaining vadose zone VOC contaminants will no longer cause concentrations in the leachate to exceed the aquifer cleanup level. If it is demonstrated that there is no water moving through the vadose zone and no potential for leachate to be produced at the current time or in the future, the parties agree that the demonstration that the remaining vadose zone VOC contaminants will no longer cause concentrations in the leachate to exceed aquifer clean-up levels has been made.

The SVE system will be operated until it is demonstrated that VOC removal from the vadose zone is no longer technically and economically feasible in order to meet the aquifer cleanup levels sooner, more cost effectively, and more reliably. This feasibility analysis will include consideration of the follow factors (these factors are not dispositive and other factors may be considered upon agreement of the parties):

1) Whether the predicted concentration of leachate from the vadose (using an appropriate vadose zone model that interprets soil gas data) will exceed the ground water cleanup standard;

2) Whether the predicted concentration of the leachate from the vadose zone (using an appropriate vadose zone model that interprets soil gas data) will cause the ground water to exceed the aquifer cleanup levels;

3) Whether the mass removal rate is approaching asymptotic levels after temporary shutdown periods and appropriate optimization of the SVE system;

4) The additional cost of continuing to operate the SVE system at concentrations approaching asymptotic mass levels;

5) The predicted effectiveness and cost of further enhancements to the SVE system (e.g., additional vapor extraction Wells, air injection) beyond system optimization of the existing system;

6) Whether the cost of ground water remediation will be significantly more if the residual vadose zone contamination is not addressed;

7) Whether residual mass in the vadose zone will significantly prolong the time to attain the ground water cleanup standard;

8) Historic data that present the SVE system operating costs per unit VOC mass removed from the vadose zone and the concurrent soil vapor VOC concentrations, both as a function of time; and

9) Historic data that present the ground water extraction and treatment system operating costs per unit VOC mass removed from the ground water and the concurrent ground water VOC concentrations, both as a function of time.

Other factors may be considered upon agreement between DOE, U.S. EPA, CVRWQCB, and DTSC.

The SVE system may be cycled on and off in order to optimize SVE operation and/or to evaluate the factors ligted above. DOE, U.S. EPA, CVRWQCB, and DTSC will jointly make the decision that VOC cleanup of the vadose zone has been achieved and the SVE system may be

shut off permanently.

If at some later date, DOE, U.S. EPA, CVRWQCB, and DTSC determine that it is technically or economically infeasible to reduce VOCs in the vadose zone to levels which no longer cause concentrations in the leachate to exceed aquifer cleanup levels, after all reasonable efforts have been made, the parties will re-evaluate the need to achieve this goal, provided that VOCs have been removed from the vadose zone to the extent technically and economically feasible and to the satisfaction of the DOE, U.S. EPA, CVRWQCB, and DTSC. This situation will require a more rigorous feasibility analysis because the incremental benefit of removing VOCs from the vadose zone is generally much higher as long as there are VOC contaminants in the vadose zone that cause concentrations in the leachate to exceed aquifer cleanup levels. Aquifer cleanup goals must be met even though the goal to reduce VOCs in vadose zone to levels that no longer cause concentrations in the leachate to exceed aquifer cleanup levels is not achieved.

Throughout the remediation process, innovative remediation technologies will be considered to enhance VOC mass removal and treatment of soil vapor, as discussed in Section 2.9.4.

Once the ground water has reached cleanup levels, DOE, U.S. EPA, CVRWQCB, and DTSC agree that:

1) It is not technically and economically feasible to operate the SVE beyond the point where the remaining vadose zone VOC contaminants no longer cause the concentrations in the leachate to exceed the aquifer cleanup level; and

2) There is relatively little benefit in continuing SVE because aquifer cleanup levels have been achieved and contaminants in the vadose zone will not cause contaminant concentrations in ground water to increase.

2.9.4. Innovative Technologies

Innovative technologies that shorten cleanup time, improve cleanup efficiency, and reduce cost will continue to be considered for application at the GSA throughout the remediation process. These technologies may be employed at the GSA if site conditions change or technology development and testing indicate a potential for cost-effective and expedited remediation. Innovative technologies will be employed with regulatory agency concurrence.

2.9.5. Reporting

Performance summaries for the ground water and soil vapor extraction and treatment systems will be submitted to the U.S. EPA, DTSC, and the CVRWQCB on a quarterly basis. A schedule for submitting ground water and vadose zone monitoring data and contaminant plume concentration contour maps will be included in the remedial design document.

2.9.6. Summary of Preliminary Cost Estimates

The 1995 present-worth cost of the selected remedy is estimated to be approximately $18.90 million as detailed in Table 10. Many of the costs for technology development, equipment purchases, and facility construction associated with the implementation of the selected remedy presented in Table 10 have already been incurred. This cost estimate assumes up to 10 years of SVE and monitoring, up to 10 years of ground water extraction in the eastern GSA, up to 55 years of ground water extiaction in the central GSA, and up to 60 years of ground water monitoring. These time and cost estimates do not include the development, testing, or implementation of innovative technologies. Cost estimates and equipment may change as the result of modifications during the remedial design and construction processes. Cleanup goals and cleanup time estimates can be re-evaluated with the regulatory agencies every five years, based on the effectiveness of the remediation system, changes in site conditions, and changes in regulatory requirements.

2.10. ARARs

CERCLA Section 121 (d)(2)(A) requires that remedial actions meet any Federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate. CERCLA Section 121 (d)(2)(A)(ii) requires that State ARARs be met if they are more stringent than Federal requirements.

There are three general kinds of ARARs:

1. Chemical-specific requirements that define acceptable exposure concentrations or water quality standards,

2. Location-specific requirements that may restrict remediation activities at sensitive or hazard-prone locations such as wildlife habitat and floodplains, and

3. Action-specific requirements that may control activities and/or technologies.

A list of potential ARARs related to the three proposed remedial alternatives was presented in the GSA FS. ARARs directly related to the selected remedy is contained in Table 11 of this ROD. These ARARs: 1) cite the most directly pertinent requirements related to specific actions to be taken as part of the selected remedy, and 2) provide a mechanism for enforcement of standards directly related to the selected remedy (i.e., NPDES waste water discharge and air discharge permits). When State ARARs are more stringent than Federal requirements, only the State ARAR is listed in the table.

2.10.1. Chemical-Specific ARARs

SWRCB Resolution 92-49 entitled "Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304" is a chemical-specific ARAR for aquifer (ground water) remediation goals. Resolution 92-49 provides general policies on investigation, monitoring, and reporting. All ground water cleanup activities associated

with
implementation of the selected remedy for the GSA will be conducted under the supervision of the CVRWQCB and in accordance with Resolution 92-49. In i addition, Resolution 92-49 authorizes the CVRWQCB to determine cleanup goals which must consider cost effectiveness and technical feasibility.

DOE, the U.S. EPA, State DTSC, and CVRWQCB have agreed to a cleanup goal of drinking water standards (MCLs) for VOCs in ground water in the GSA OU, except as specified below. This cleanup goal is based on the chemical-specific ARARs (State and Federal MCLs) established in the Federal Safe Drinking Water Act and California Safe Drinking Water Act. The Federal and State MCLs for the chemicals of concern in ground water in the GSA OU are given in Table 9. The most stringent concentration limit, in most cases the State MCL, is the
governing ARAR for each chemical of concern and will be the cleanup goal for ground water remediation in the GSA.

The CVRWQCB's decision to concur with MCLs as ground water cleanup goals was based on technical and economic information in the GSA FS. The CVRWQCB stated "LLNL/DOE presented costs and time needed to cleanup to MCLs and non-detect for TCE. Based on numerical fate and transport modeling, LLNL/DOE showed that concentrations of TCE would be below the limit of detection (0.5 ppb [µg/L]) in all but a 12-acre area in the vicinity of the GSA
after 55 years of pumping. The 12-acre area would be below the MCLs, except for an approximately 100 ft-square area at 5 to 10 ppb (µg/L). Simulation TCE fate and transport for
an additional 35 years (without pumping) showed TCE contamination at or below 1 ppb (gg/L), except for about a 100 ft-square area which would be at or below the MCL. LLNL/DOE also simulate 90 years of pumping, which showed that TCE concentrations would be at or below ppb (µg/L) in all locations. The Board agrees that 35 years of additional pumping for achieving the small amount of mass removal is not economically feasible." However, if remediation does not show that cleanup is proceeding as the modeling predicts, remediation methods will be revisited.

The CVRWQCB and the U.S. EPA do not concur with the selection of MCLs as the cleanup goal for chloroform and bromodichloromethane, because the MCL for total trihalomethanes is based on the economics of chlorinating a municipal water supply to remove pathogens and therefore does not adequately protect the beneficial uses of a drinking water source that has not
been, and may not be, chlorinated. The modeling as described in Appendix E of the GSA Feasibility Study predicts that TCE in the area where chloroform and bromodichloromethane are
found will be cleaned tip to five to ten parts per billion (ppb) after 55 years of pumping. The
agencies predict that this will result in cleanup of chloroform and bromodichloromethane to 1.1 ppb and 0.27 ppb, respectively. If the remediation does not show that cleanup is proceeding
as predicted, the cleanup goals for chloroform and bromodichloromethane will be revisited, following the procedure to be outlined in the GSA OU Compliance Monitoring and Contingency Plan.

The CVRWQCB believes that the California Safe Drinking Water and Toxic Enforcement Act of 1986, Health and Safety Code Section 25249.5 et seq. (Proposition 65) is an ARAR for the establishment of in situ ground water cleanup levels. DOE has not included Proposition 65
as an ARAR in this ROD because federal agencies are exempt from its requirements (California

Health and Safety Code Section 25249.11). The CVRWQCB will not dispute the ROD, however, because the cleanup of the listed constituents will meet or exceed Proposition 65 levels.

Because numerical standards or chemical-specific ARARs for cleanup of contaminants in soil vapor have not been established, DOE and the regulatory agencies agreed upon a cleanup goal for soil vapor which is protective of ground water as discussed in Section 2.9.1.2. The objective is to reduce VOC mass in the vadose zone to levels protective of ground water and remediate VOCs in the vadose zone to the extent technically and economically feasible to minimize further degradation of ground water by contaminants in the vadose zone. DOE, U.S. EPA, and the State disagree on the applicability of SWRCB Resolution No. 92-49 and the CVRWQCB's Water Quality Control Plan with respect to using water quality objectives to establish soil vapor cleanup levels. The State concurs with this ROD, however, because it believes that the standard in Sections 2.9.1.2 and 2.9.3.2 complies with those requirements. This ROD does not resolve the ARAR status of State requirements regarding the establishment of soil cleanup levels.

Chapter 15, CCR Title 23, Sections 2550.7 and 2550.10 are chemical-specific ARARs, which require the monitoring of the effectiveness of remedial actions. In accordance with these ARARs, in situ concentrations of VOCs in ground water and soil vapor will be measured during and after the completion of the selected remedy for the GSA OU to monitor its effectiveness in achieving cleanup goals.

State Board Resolution No. 88-63 (Sources of Drinking Water Policy) designates all ground and surface water of the State as drinking water except where the TDS is greater than 3,000 ppm, the water source does not provide sufficient water to supply a single well more than 200 gallons per day, the water is a geothermal resource or in a waste water conveyance facility, or the water cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices.

Chemical-specific ARARs related to the discharges of waste resulting from remediation activities include: 1) the SWRCB Resolution 68-16, which is applicable to the discharge of treated ground water from the remediation systems, and 2) the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) Rules 463.5 and 2201 regulating the discharge of treated vapor. Treated ground water will be discharged according to the requirements of the NPDES Permit (Order No. 91-052) for the eastern GSA and the Substantive Requirements for the central GSA. These permits are administered by the CVRWQCB. The discharge standards under the current permits require that the monthly median VOC concentration in ground water are reduced to below EPA Method detection limits for VOCs (<0.5 µg/L), prior to discharge. Treated vapor will be discharged according to the requirements of the "Authority to Construct" or "Permit to Operate" issued by the SJVUAPCD, which currently requires that VOC concentrations in vapor be treated to 6 ppm v, prior to discharge to ambient atmosphere.

2.10.2. Location-Specific AR.ARs

Location-specific ARARs are restrictions placed on the concentration of chemicals or conduct of operations based on the location of a site. Potential location-specific ARARs include the protection of:

- Wetlands.
- Floodplains.
- Historic landmarks.
- Coastal zones.
- Coastal barriers.
- Rare and endangered species.
- Cultural resources.

The GSA does not contain any historic landmarks, coastal zones, or coastal barriers. No wetlands have been identified within the area of the GSA where the remedial action would occur.

Although the GSA OU is located adjacent to the 100-year floodplain associated with Corral Hollow Creek, no portion of Site 300 lies within the floodplain. 22 CCR 66264.18(B)(1) states that TSD facilities within a 100-year floodplain must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood. If it became necessary to install POU treatment for water-supply well CON-1, which is located offsite within the 100-year floodplain, the system would be constructed in accordance with this requirement.

Archaeological and ecological surveys conducted in the GSA are described in Chapter 6 of the SWRI and the Site 300 EIR/EIS (U.S. DOE, 1992), respectively. Additional surveys to identify potential cultural resources and the presence of sensitive (rare, threatened, or endangered) species will be conducted, as necessary, prior to all ground-breaking activities associated with remediation in the GSA in order to mitigate any adverse impacts of the project.

In addition, the discharge of treated water to Corral Hollow Creek that could affect endangered species that may be in the California Department of Fish and Game ecological preserve downstream, is regulated through the NPDES permit for the eastern GSA treatment facility.

2.10.3. Action-Specific ARARs

Action-specific ARARs are usually technology- or activity-based limitations on actions taken with respect to hazardous wastes. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. For the selected remedy, there are two action-specific ARARs which are related to: 1) monitoring of the reinjection of treated water, and 2) the management of hazardous wastes generated as a result of remedial activities. All treated water to be reinjected will be analyzed/monitored prior to reinjection in accordance with the requirements of the Safe Drinking Water Act Underground Injection Control Program (40 CFR 144.26-144.27). All hazardous waste generated as the result of the selected remedy,

primarily spent GAC, will be handled in accordance with the requirements of CCR, Title 22, Chapter 30 and the Health and Safety Code, Sections 25100-25395.

2.10.4. Other Applicable Standards

There are no ARARs as cleanup standards for contaminants in the vadose zone that may present an inhalation risk to human health. Therefore, a cumulative potential excess cancer risk of 10-6 (one in one million) will be used as the cleanup goal for mitigation of VOC inhalation risk inside Building 875 as specified in the NCP (U.S. EPA, 1990a).

As discussed in Section 2.11.2, the selected remedy meets ARARs by actively remediating VOCs in soil and ground water to protect human health and the environment.

2.11. Statutory Determinations

The selected response action for the GSA OU satisfies the mandates of CERCLA Section 12 1. The remedy will:

- Protect human health by reducing risk from soil vapor inhalation and by achieving ground water remediation goals.
- Comply with ARARs.
- Provide both short-and long-term effectiveness.
- Reduce contaminant toxicity, mobility, or volume as a principal element.
- Be readily implementable.
- Provide the most cost-effective means of achieving remediation goals.

DOE, U.S. EPA, CVRWQCB, and DTSC believe that among the three proposed remedial alternatives, Alternative 3b provides the best balance of trade-offs with respect to the CERCLA evaluation criteria. Site 300 will remain under the control and ownership of DOE for the foreseeable future. This is a major factor in defining the scope of the remedy proposed in this ROD. A brief description of how the selected remedy satisfies each of these statutory requirements, as well as state and community acceptance, is provided below.

2.11.1. Overall Protection of Human Health and the Environment

The selected remedy uses exposure control methods, such as contingency POU treatment and administrative controls, to provide initial protection to human health. It also provides long-term protection to human health by restoring and protecting the beneficial use of the Tnbsl regional aquifer and potential beneficial use of the alluvial aquifer through active remediation to reduce VOC concentrations in ground water to MCLs.

The selected remedy prevents potential inhalation of VOCs above health-based concentrations in Building 875 by reducing soil vapor VOC concentrations through soil vapor extraction.

All extracted soil vapor and ground water will be treated before discharge to the environment. Soil vapor and ground water monitoring will document the progress and permanence of all remediation methods.

The selected remedy employs ecological surveys and appropriate response actions, if necessary, to protect the environment. By actively reducing VOC concentrations in soil vapor and ground water, potential future ecological risks are mitigated.

In accordance with a DOE Secretarial Policy issued in June 1994, National Environmental Policy Act (NEPA) values contained in the Environmental Considerations chapter of the GSA FS satisfy the requirements for CERCLA-NEPA integration. As part of these requirements, the potential impacts on the existing onsite and offsite environment due to implementation of the remedial alternatives were evaluated. No significant adverse impacts due to implementation of the alternatives were identified.

2.11.2. Compliance with ARARs

Federal and State chemical-, location-, and action-specific ARARs affecting the selected remedy are described in Table 11. The selected remedy meets all ARARs. Ground water and soil vapor extraction will reduce VOC concentrations to MCLs in ground water in the GSA OU, as well as reduce inhalation risk inside Building 875 to health-protective levels.

2.11.3. Short-Term Effectiveness

The selected remedy immediately protects the public from existing exposure pathways through exposure controls: contingency POU treatment and administrative controls. It also uses ground water and soil vapor extraction to continue to remove VOC mass and reduce VOC concentrations in ground water and soil vapor. It provides measures for the protection of site workers and the community during remedial actions. No adverse environmental impacts are anticipated.

2.11.4. Long-Term Effectiveness and Utilization of Permanent Solutions

The selected remedy provides long-term effectiveness through contaminant mass removal that will: 1) reduce VOC concentrations to MCLs in all affected ground water, and 2) reduce VOC soil vapor concentrations to levels protective of ground water and to acceptable health inhalation risk levels. Monitoring will be continued for five years after discontinuing ground water extraction to ensure long-term effectiveness and permanence.

2.11.5. Reduction of Contaminant Toxicity, Mobility, or Volume as a Principal Element

Contaminant toxicity, mobility, and volume in the soil and ground water will be reduced irreversibly by ground water and soil vapor extraction. In addition, SVE will significantly reduce the toxicity, mobility, and volume of both dissolved and undissolved (DNAPL) contaminants in the subsurface, enhance the progress of VOC removal, and be more protective of the environment than if only ground water extraction was used.

2.11.6. Implementability

The selected remedy can be readily implemented utilizing existing soil vapor and ground water extraction and treatment systems that are permitted and operating in the GSA. Modifications to these systems are readily implementable.

2.11.7. Cost Effectiveness

DOE, U.S. EPA, CVRWQCB, and DTSC agree that Alternative 3b provides the most cost-effective means of remediating VOCs in soil and ground water to levels protective of human health and the environment. The cost of this alternative was estimated on the basis of a preliminary engineering design to reduce inhalation risk, remove VOC mass, and reduce VOC concentrations in ground water to MCLs.

2.11.8. State Acceptance

The California DTSC and CVRWQCB provided ARARs which were used as the basis for developing the selected remedy. These State agencies reviewed and evaluated the remedial technologies and alternatives and participated in the selection of the final remedy and provided oversight and enforcement of state environmental regulations. In addition, the regulatory agencies have monitored and reviewed public acceptance of the final selected remedy.

2.11.9. Community Acceptance

Public comments concerning the selected remedy have been considered and used, as appropriate, in the preparation of this ROD. All public comments are addressed in the Responsiveness Summary section of this document.

Any proposed changes to the ROD, such as the implementation of new remedial alternatives or innovative technologies, re-evaluation of the technical and economic feasibility of achieving cleanup goals, etc., will be submitted to the regulatory agencies for review and approval. Community members will be informed of any ROD change, and would be provided with the opportunity to comment on significant or fundamental ROD changes. Following EPA guidelines (U.S. EPA, 1991), the lead agency determines if the proposed ROD change is: 1) nonsignificant or minor,2) significant, or 3) fundamental.

3. Responsiveness Summary

This section responds to public comments directed to DOE, LLNL, U.S. EPA, and the State of California regarding the Proposed Plan for remediation of the GSA OU. Responses to community comments and concerns are incorporated into this ROD.

The public comment period on the Proposed Plan began April 10, 1996, and ended May 10, 1996. On April 24,1996, DOE/LLNL and the regulatory agencies held a public meeting at the Tracy Inn in Tracy, California to present the proposed remediation plan and allow the public to ask questions and comment on the preferred remedial alternative. Representatives from LLNL summarized the information presented in the FS and Proposed Plan. Following the presentation, three members of the public read their concerns into the formal public record. Although no letters were received during the Propoted Plan comment period, members of the Tri-Valley Citizens Against a Radioactive Environment (CAREs) provided a written record of their meeting comments. The meeting transcript and a copy of the written concerns are available to the publi6 at the LLNL Visitors Center and the Tracy Public Library.

3.1. Organization of the Responsiveness Summary

This Responsiveness Summary is organized to clearly present the breadth of public concerns while minimizing repetition. In keeping with EPA Superfund guidance and accepted practice, comments are grouped by subject. Whenever possible, comments are summarized verbatim from either the meeting transcript or written comments.

Public comments are grouped into the following sections:

- Selected Remedial Action.
- General Comments.

3.2. Summary of Public Comments and Responses

3.2.1. Selected Remedial Action

Comment 1:

Before the Proposed Plan is approved, it is important that the monitoring plan be specified, (number of wells, depth of wells, frequency of sampling, duration of sampling, approximate location of wells) and that a contingency plan be specified which delineates what the Lab is committed to do should itfind that the plume is moving, or is not being remediated in the time-frame expected. This should be similar in content to the way contingency was addressed in the document entitled "Remedial Alternatives for the Building 815 Operable Unit. " There, specific information regarding what the Lab was prepared to do if the plume migrated past a certain point was established.

Response to Comment No. 1:

A preliminary monitoring plan was presented in the FS to support cost estimates for each remedial alternative. This preliminary monitoring plan presented the number of wells and the frequency and duration of sampling. The depths and approximate locations of these wells were also included in the FS. This information was not reiterated in the Proposed Plan, which is intended to be a brief summary document. Consistent with EPA guidance and practice at other U.S. EPA Superfund sites, the GSA monitoring program will be presented in the Remedial Design document. As specified in the Site 300 FFA, a discussion of the schedule for the Remedial Design for the GSA will be initiated within 15 days of the signing of the Final ROD, which is scheduled for January 1997.

A formal review of remediation progress is required to be conducted at least every five years to ensure that the selected remedy is effective and continues to adequately protect human health and the environment. However, the evaluation of the progress of remediation will be an on-going, continuous process. Progress of site cleanup will be published in periodic progress reports. If monitoring data indicate that the selected remedy is not effectively remediating the site, DOE/LLNL and the regulatory agencies will evaluate whether to consider another remedial alternative.

Comment 2:

The plan should contain milestones by which the success of the subsequent remediation can be evaluated. In almost all Superfund cleanup projects, commitments and milestones concerning the cleanup performance (e.g., timing of cleanup, how much contaminant will be removed) are disregarded in Records of Decision. We regard this as a fundamental problem with the government's approach to CERCLA enforcement. For example, we suggest that a timetable for cleanup be established. This could be based on performance milestones such as the amount of contaminant mass that is removedfrom the soil and groundwater within an expected time period, and regulatory milestones such as achieving cleanup standards or showing a trend towards meeting cleanup standards. This timetable would then be used to monitor the performance of cleanup, and provide interested parties with some idea how cleanup will progress. As it now stands, after a final ROD is signed, the only legal requirements are that substantial on-site remedial action be commenced within 15 months and that the cleanup program be subject to a five-year review. It is important that the Proposed Plan contain a measurable schedule and performance standards which can be verified.

Response to Comment No. 2:

Consistent with U.S. EPA Superfund guidance and as specified by the CERCLA process, schedules and performance milestones will be presented in the GSA Remedial Design document. As specified in the Site 300 FFA, a discussion of the schedule for the Remedial Design document for the GSA will be initiated within 15 days of the signing of the ROD, which is scheduled for January 1997.

DOE will make the Remedial Design document available to the public as part of the CERCLA public participation process. The public will have an opportunity to review and

comment on the Remedial Design document. If concerns or issues concerning the Remedial Design document are identified on the part of the public and regulatory agencies, a public meeting may be considered.

The Remedial Design document will define in detail the technical parameters, design criteria and components, and assumptions of the Remedial Action including:

1. Waste characterization,
2. Pretreatment requirements,
3. Volume and types of each medium requiring treatment,
4. Treatment schemes, rates, and required qualities of waste water streams,
5. Performance standards,
6. Long-term performance monitoring and O&M requirements,
7. Compliance with all ARARs, codes, and standards,
8. Technical factors of importance to the design and construction,
9. Construction schedule,
10. Cost estimates,
11. Variances with the ROD, if necessary,
12. Land acquisition and easement requirements, and
13. Value Engineering Screening (including an evaluation of cost and function relationships, concentrating on high-cost areas.

The final Remedial Design must be approved by the regulatory agencies before initiating the Remedial Action. Cleanup standards are included in Section 2.9.1 of this ROD.

A formal review of remediation progress is required to be conducted at least every five years to ensure that the selected remedy is effective and continues to adequately protect human health and the environment. However, the evaluation of the progress of remediation will be an on-going, continuous process.

If the selected remedy fails to meet the criteria set forth in the design documents,

and the regulatory agencies will evaluate whether to consider another remedial alternative.

Comment 3:

I want to emphasize the need for contaminant reduction milestones as a method of determining not only how well the cleanup is doing, but whether or not the cleanup's budget year to year is sufficient. Right now, and this is a problem we are running into at the Main Site to some extent, and in other sites as well, where the milestones are defined as production of documents, we are going to have a remedial design document by thus and such a date or the milestone is the putting in of a monitoring well or the construction of an extraction well irrespective of whether those things alone. Well obviously the production of the document

doesn't actually remediate the site, irrespective of whether those things alone together are going to accomplish the cleanup and keep it on schedule.

In saying you have a 55-year cleanup time, somebody has done a curve. I mean, you are figuring you are going to peg down the contaminant levels by certain amounts to get to cleanup in 55 years. If you made them explicit, that would give the citizens a way to track how the cleanup is doing, say, in five-year increments and that the cleanup was falling behind, we would then have something we could use in saying our community needs some more money to get this back on track. None of us wants to wait 55 years, which means our children and in some cases our children's children will then say oh that wasn't enough, it isn't cleaned up.

So we really (the public) need this stuff to be codified in the Record of Decision to help watch dog and ensure a full cleanup. As Peter mentioned, mass removal milestones is another entree into the same type of result.

Response to Comment No. 3:

As stated in the response to Comment 2, schedules and performance milestones will be presented in the design document; consistent with U.S. EPA Superfund guidance and as specified by the CERCLA process. Budgetary issues are discussed in the response to Comment 17.

The 55-year projected time to reduce VOC ground water concentrations in the central GSA to MCLs was based on remediation and contaminant fate and transport modeling presented in the GSA FS. The modeling for the selected remedy (Alternative 3b) was discussed in Section E-2.9.2.2 of the FS, and presented simulated VOC ground water concentrations for 10, 30, 55, and 90 years after initiation of remediation.

The modeling indicated that the selected remedy utilized the optimum number and configuration of extraction wells for the most cost- and time-effective remediation of the GSA. Although this modeling was conducted primarily for the purposes of determining cost, it estimates remediation progress. Additional modeling using current data may be conducted

during the five-year review to evaluate remediation progress.

Comment 4.

The Proposed Plan or the ROD should identify criteria it will use to determine whether a remedy should be replaced with a new remedy, or that remediation should be discontinued. In the case of the former, there are many new development activities which may improve upon the selected remedy. At some time in the future there may be a decision to replace old technology.
The (Proposed Plan) or the ROD should outline what decision criteria will be used to re-assess
the proposed technology. In addition, there has been a trend at some sites to stop remediation
on the grounds of "Technical Impracticability". The (Proposed Plan) or the ROD should outline the decision criteria that would be used to make such a determination, as the decision
will not be subject to the same level of public scrutiny as is the ROD.

Response to Comment No. 4:

The decision criteria that will be used to determine:

1. When remediation should be discontinued are discussed in Section 2.9.3 of the ROD.

2. Whether to replace the technologies outlined in the ROD are discussed in Section 2.9.4 of
   the ROD.

3. When to cease remediation activities based on Technical Impracticability are discussed in
   Section 2.9.3 of the ROD.

U.S. EPA's OSWER Directive 9234.2-25, "Guidance for Evaluating the Technical Impracticability of Ground Water Restoration" (EPA, 1993c), provides guidance for evaluating Technical Impracticability. If the cleanup levels are changed due to Technical Impracticability,
an ARARs waiver will be obtained and a ROD amendment will be necessary.

Throughout the remediation process, innovative remediation technologies will be considered to enhance VOC mass removal and treatment of soil vapor, as discussed in Section 2.9.4.

In addition, a review will be conducted every five years after commencement of the remedial
action to ensure that the remedy continues to provide adequate protection of human health and
the environment.

Comment 5.

If the Proposed Plan could contain some more detail about the types of treatment technologies that are being considered, a little bit of data on the effectiveness of the

treatment technologies being used as pilot projects so that we could then discuss in greater detail, what kind of suite of treatment technologies we might want to codify in the Record of Decision. That would make for a much higher sort of level of decision.

Response to Comment No. 5:

The types of treatment technologies considered for implementation at the GSA, including the technologies included in the selected remedy, were screened and discussed in detail in the GSA FS. The effectiveness of the existing treatment systems was also evaluated and discussed in the GSA FS. The Proposed Plan is designed to be a brief summary of the major components of the evaluated alternatives and the preferred remedy that are discussed in detail in the FS.

Comment 6.

The criteria for choosing treatment technologies need to be a part of the Record of Decision.

Response to Comment No. 6:

Consistent with U.S. EPA Superfund guidance, the criteria for choosing treatment technologies was presented in the GSA FS, where each treatment technology was screened and discussed. See also response to Comment No. 3.

Comment 7.

Remedial action objectives should be identified in the Proposed Plan and include:

i) Protect human health and ecological receptors from contact with contaminated groundwater, soil or air;

ii) Attain the preliminary remediation goals (PRGs) set by EPA Region 9. (PRGs are remediation goals with an estimated health risk of one in one million additional cancer deaths);

iii) Conduct cleanup in such a way as to minimize time for remediation;

iv) In the Central GSA, continue efforts to remove contaminant massfrom the ground water and soil and locate the source of dense non-aqueous phase liquid (DNAPL).

Response to Comment No. 7:

i) Section 2.5 of the FS defines Remedial Action Objectives (RAOs) which are media-specific goals for protecting human health and the environment. EPA guidance indicates that RAOs are to specify exposure routes for which potentially unacceptable risk has been identified, contaminants of concern, and an acceptable contaminant concentration

or
range of concentrations. We have addressed these points in the RAOs. Cleanup goals are discussed in Chapter 4 of the FS and are specified in more detail in Section 2.9.1 of this ROD.

ii) The U.S. EPA, and the State DTSC, and CVRWQCB have concurred with a cleanup goal of MCLs for VOCs in ground water in the GSA OU. The CVRWQCB's decision to concur with MCLs as ground water cleanup goals was based on technical and economic information in the Final FS for the GSA OU. The CVRWQCB stated "LLNL/DOE presented costs and time needed to cleanup to MCLs and nondetectable for TCE. Based on numerical fate and transport modeling, LLNL/DOE showed that concentrations of TCE would be below the limit of detection (0.5 ppb µg/L]) in all but a 12-acre area in the vicinity of the GSA after 55 years of pumping. The 12-acre area would be below the MCLs, except for an approximately 100 ft-square area at 5 to 10 ppb (µg/L). Simulation TCE fate and transport for an additional 35 years (without pumping) showed TCE contamination at or below 1 ppb (µg/L) except for about a 100 ft-square area, which would be at or below the MCL. LLNL/DOE also simulate 90 years of pumping, which showed that TCE concentrations would be at or below 1 ppb (µg/L) in all locations. The Board agrees that 35 years of additional pumping for achieving the small amount of mass removal is not economically feasible. However, LLNL/DOE will be required to review the remedial system every five years to determine if the remedial objectives are being

met. LLNL/DOE will optimize the system or propose an alternative remedial method if the plume is not being remediated as projected."

MCLs are health based and equivalent to an excess cancer risk of 10 -6, or one in one million, with consideration given to technologic and economic factors. U.S. EPA Region IX Preliminary Remediation Goals, according to EPA, "can be used as a rapid reference for screening concentrations in environmental media, as 'triggers' for further investigation at CERCLA/RCRA sites, and as initial cleanup goals, if applicable." The NCP (U.S. EPA, 1990a) states that "PRGs should be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected." Remediation goals are developed by considering ARARs under Federal or State environmental laws. The NCP also states that the "10 -6 risk level shall be used as the point-of-departure for determining remediation goals for alternatives when ARARs are not available."

iii) The preferred remedy is designed to achieve soil and ground water cleanup goals in a time-effective manner using proven, implementable technologies. Other remediation scenarios were evaluated, such as installing more wells to determine if an increased ground water extraction rate would expedite cleanup. Modeling indicated that the selected remedy provided the most expeditious, cost-effective means of remediating the GSA OU.

iv) The selected remedy (Alternative 3b) includes both ground water and soil vapor extraction to remove contaminant mass from ground water and soil in the central GSA. Based on historical and sampling data, DNAPLs may be present in the vicinity of the Building 875 dry well pad where the SVE remediation. efforts are concentrated. The only wells in the GSA where ground water sample data indicate the possible presence of DNAPLs (TCE concentrations >11,000 ppb) are wells W-875-07,-08,-09,-10,-11,-15,

and W-7L These wells are all located in the Building 875 dry well pad area in the central GSA. The source of DNAPLs in this area was the wastewater disposed in the two former dry wells, 875-S1 and 875-S2, located south of Building 875. No other wells in the GSA have contained VOCs in ground water in concentrations indicative of DNAPLs, including wells located at other source areas. We have therefore concluded that the DNAPLs are confined to the Building 875 dry well pad area in the central GSA. SVE has been identified as a technology that can effectively remediate DNAPLs in the vadose zone.

Throughout the life of the remediation project, continued efforts will be made to evaluate whether DNAPLs act as a continuing source of contamination. The methodology and schedule for the evaluation of DNAPLs will be included in the remedial design document. The objective of these investigations is to validate whether the assessment of the location of DNAPLs, as well as efforts to remediate DNAPLs, are properly focused.

Comment 8:

The Proposed Plan should include a continued search for the location of DNAPLs in the central GSA, and the testing and or development of new technologies to extract DNAPL, until monitoring conclusively proves that they are no longer present'in the area. It does not appear that the DNAPL problem will be solved by the Proposed Plan. Without removal of DNAPL, the

site will act as a continuing source of contamination, and may reverse the progress that has been made in cleanup over the past several years. While DNAPL or potential DNAPL exists at many sites that I am aware of, solutions are elusive without knowing the precise location. I suggest the (Proposed Plan) identify how many quarters (or years) that monitoring will be required to show that DNAPLs are no longer present.

Response to Comment No. 8:

As discussed in Chapters 1 and 4 of the FS, residual DNAPLs may exist in soil in the dewatered zone and/or vadose zone in the central GSA in the vicinity of the Building 875 dry well pad, as discussed in the response to Comment No. 7 (iv). Data from other nearby wells and wells in other source areas allows us to conclude that DNAPLs are confined to the Building 975 dry well area.

The preferred remedy (Alternative 3b) includes SVE, which has been identified as a technology that can effectively remediate DNAPLs in the vadose zone (U.S. EPA, 1992d, 1993b). Historical sampling data indicate that DNAPLs may be in the vicinity of the Building 875 dry well pad where the SVE remediation efforts are concentrated. Ground water, soil, and soil vapor data collected from other release areas do not indicate that DNAPLs are present. DOE/LLNL will continue to investigate and evaluate innovative technologies that may be considered for application at the GSA if they could be implemented cost effectively and

expedite remediation. Throughout the life of the remediation project, continued efforts will be made to evaluate whether DNAPLs act as a continuing source of contamination. The methodology and schedule for the evaluation of DNAPLs will be included in the remedial design document. The objective of these investigations is to validate whether the assessment of the location of DNAPLs, as well as efforts to remediate DNAPLs, are properly focused.

In general, if a ground water VOC concentration is 1 to 10% of the solubility of that VOC in ground water, then a DNAPL may be present. Because the aqueous solubility of TCE is 1,100,000 µg/L, TCE concentrations in the range of 11,000 to 110,000 µg/L or greater would indicate DNAPL. The cleanup goals established for ground water (i.e., 5 µg/L for TCE) are well below the concentrations indicative of DNAPLs (11,000 µg/L for TCE). When VOC concentrations in ground water have been reduced to cleanup goals (MCLs), the ground water extraction and treatment system(s) will be shut off and placed on stand-by. Modeling indicates that VOC concentrations in ground water in the central GSA should be reduced to MCLs within 55 years following the initiation of remediation. Ground water in the central GSA will continue to be monitored for a period of five years following shutdown of the system. This will allow tracking of,ground water VOC concentration trends in the Building 875 dry well pad area to determine if: 1) ground water VOC concentrations in the area indicate DNAPLs, and 2) the ground water remediation goal has been attained and maintained. Should VOC concentrations in ground water "rebound" or increase above cleanup goals, reinitiation of remediation efforts will be discussed with the regulatory agencies.

Comment 9.

I am concerned on a number of levels. One of them, let me just use as an example the problerm with dense non-aqueous phase liquids with the concentrations of TCE that you have at

Site 300, there probably are globs of pure TCE in there and as those dissolve over time it is going to continue as its own source of contamination and in order to get at those, you guys need money for something called source investigation. John Ziagos will remember I am big on advocating money for source investigation to make sure that you have got the information you need so that you put in the right cleanup technologies in the right places to actually achieve a cleanup. I think it's penny wise and pound foolish to neglect source investigation, so I am looking at the Department of Energy's fiscal year 1998 draft priority list and for the one that's for the Livermore Lab Main Site and Site 300. The first time I see source investigation, let me just say for the record, this line here is put at a target of what is gonna be 19.4 million dollars they plan to ask for for FY 1998 and everything that falls below this line they are not even

gonna ask for money for and the first time source investigation is mentioned is about ten listings below the line. So, there is not even any consideration that DOE is going to even ask for money that will adequately fund source investigation in the time frame when you are really gonna need that money. So codifying something in the'Record of Decision is a way to ensure that that gets bumped up, because then it becomes a legal requirement and it suddenly is part of what becomes necessary and not optional and in my opinion, some of these things, I mean, all of these that I am talking about are necessary.

So then I looked at how it rates in the field office where the lab has to compete against the other DOE facilities and its four from the bottom on page 5. So if it isn't codified in the Record of Decision, I kind of think that you are probably not gonna get the money to do it and you are going to have on going problems that will threaten the entire cleanup because there is not the money to go out and do the source investigation needed to fimd the DNAPLs and also some of the other important parameters before cleanup can be accomplished.

Response to Comment No. 9:

Based on historical sampling data described in the response to Comment No. 7 (iv) and our extensive source investigations presented in the SWRI and FS, we have concluded that DNAPLs are confined to the Building 875 dry well pad area in the central GSA. The source of potential DNAPLs in this area was the wastewater disposed in the two former dry wells 875-S1 and 875-S2 located south of Building 875. No other wells in the GSA have contained VOCs in ground water indicative of the presence of DNAPLs. Because the source of the DNAPLs has been confirmed as the two former dry wells 875-S1 and 875-S2, located south of Building 875, and analytical data confirms that the DNAPLs are confined to the vicinity of the Building 875 dry well pad, no additional source investigation for DNAPLs in the GSA is planned at this time. TCE concentrations in ground water in GSA monitor wells will be monitored throughout the life of remediation. If future ground water analytic data indicate that DNAPLs have migrated or are present in other areas of the GSA, changes to the remediation system(s) to address the presence/remediation of DNAPLs will be considered at that time.

Throughout the life of the remediation project, continued efforts will be made to evaluate whether DNAPLs act as a continuing source of contamination. The methodology and schedule for the evaluation of DNAPLs will be included in the remedial design document. The objective of these investigations is to validate whether the assessment of the location of DNAPLs, as well as efforts to remediate DNAPLs, are properly focused.

Comment 10:

I think essentially the points that both Peter Strauss and Marylia Kelly have made about looking for these DNAPLs, as they are called, looking for the source of contamination which obviously could have an impact on the cleanup and how fast or how easy it would be to achieve certain milestones, which I do believe should be in place, are critical.

Response to Comment No. 10:

See responses to Comments Nos. 7 (iv) and 9. The potential presence of DNAPLs in the central GSA was factored into the ground water modeling conducted for the selected remedy. This modeling was the basis for estimating cleanup time for the selected remedy.

Comment 11:

The Lab must demonstrate that natural attenuation is actually occurring at this OU. At the main site, early modeling factored in natural attenuation to calculate cleanup time. A later study invalidated this assumption. There has not been, to the best of my knowledge, conclusive evidence that natural attenuation is a relevant factor in the cleanup of TCE at Site 300, although models on the length of time for cleanup may use this assumption. For example, vinyl chloride is a natural breakdown product of TCE. TCE has been found at extremely high concentrations in the GSA, yet the baseline health risk assessment does not include an assessment of vinyl chloride because it has not been found at Site 300. Vinyl chloride is a known human carcinogen, and is harmful at very low concentrations, i.e., 0.5 ppb is the drinking water standard for vinyl chloride.

Response to Comment No. 11:

The selected remedy (Alternative 3b) does not rely on natural attenuation as a component of the remediation of soil or ground water in the GSA. This remedy provides for active remediation to reduce VOC concentrations in soil and ground water to levels protective of human health and the environment.

Comment 12:

Something that our group, working with a hydrologist, took a look at for the Main Site cleanup which you will recall, John Ziagos, but I would like to see you folks take a crack at this for the GSA and that is taking a look at, okay, you have a cost estimate in present dollars. What percentage of that is your capital costs and what percentage is M&O costs? How many extraction wells, etc. do you plan to put in? How many could you put in optimally and if so, how would that cut down on your 55-year cleanup time and, therefore, perhaps really cut down on the amount of cost for the cleanup overall? If it became a 30-year cleanup with some more extraction wells instead of a 55-year cleanup, perhaps the overall cost would go down dramatically. I suspect that that's true. Again, this is information, that if it were discussed and

analyzed in your documents, you could pick up some allies in the citizens groups in terms of helping implement what DOE calls the accelerated cleanup.

Response to Comment No. 12:

Capital costs represent 18% of the total cost for implementing the selected remedy, while the operation and maintenance (O&M) costs are 30% of the total., The other 52% consists of monitoring and contingency (POU treatment, etc.) costs. These percentages for the proposed alternatives, as well as the selected remedy, are shown in Figure 5-1 of the FS.

The number of extraction wells proposed for the selected remedy is discussed in Section 2.9 of this ROD. The number and location of these extraction wells were based on rhodeling that was used, in part, to determine the optimum configuration and number of extraction wells for the most cost- and time-effective removal of VOCs from the GSA. The modeling indicated that increasing the number of extraction wells, from the number currently proposed, would not significantly decrease cleanup time. However, these modeling data will be evaluated and incorporated into the final design presented in the Remedial Design document. Data obtained from future well installation may allow DOE/LLNL to optimize wellfield performance.

Comment 13:

I wanted just to emphasize a little bit aside from agreeing on the need for real milestones in achievement in cleanup which should be built in, I am particularly concerned about the budgetary aspects of this, and it occurred to me also that, as Marylia Kelly pointed out, really 3b was the only truly legal alternative and I am very pleased that the lab is, you know, proceeding forth on that track; but, if you were to consider alternatives among legal alternatives, you might be looking at alternatives with different time schedules and that, of course, also may have different budget schedules, you know, the 55-year schedule versus a 30-year or whatever and what different amount of technology that needs to be put in at the front end of that and what kind of schedule you have.

Response to Comment No. 13:

As part of the modeling conducted to estimate cleanup times, various numbers of extraction wells were evaluated to estimate the optimum configuration and number of extraction wells to achieve the most time- and cost-effective cleanup of the GSA. The optimum configuration and number was included in the ground water extraction component of the selected remedy (Alternative 3b). The modeling indicated that by increasing the number of extraction wells from that presented in the selected remedy, the time and cost of cleanup were not significantly decreased. Numerous remedial technologies were evaluated and screened as part of the GSA FS. The technologies in the selected remedy represent the best available technologies, given site conditions, currently available. DOE/LLNL will continue to evaluate innovative technologies for possible use in the GSA if innovative technologies will expedite site cleanup and/or be

more
cost effective.

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Comment 14:

The cleanup standards for TCE and other VOCs should be more stringent. Because the GSA connects with the regional aquifer, we believe that the cleanup standard should be set at the incremental lifetime cancer risk (ILCR) of one in one million (1 X 10 -6). CERCLA guidelines require cleanup to 1 x 10 -4 to 1 x 10 -6 ILCR. The Preliminary Remediation Goal (PRG) for TCE is the most current attempt to define the 1 X 10 -6 cleanup standard. The PRG for TCE is 1.8 ppb. We believe that PRGs should be adoptedfor VOCs that can migrate to the regional aquifer. I note that at two other Superfund sites where I serve as the Technical Advisor, the PRPS (in one case a private party, in another the DoD and the City of Tucson) have adopted a cleanup standard based on reducing risk to one in one million. Thus, it is clear that EPA and responsible parties can adopt these stricter standards.

Response to Comment No. 14:

The U.S. EPA, and the State DTSC, and CVRWQCB have concurred with a cleanup goal of MCLs for VOCs in ground water in the GSA OU. The CVRWQCB's decision to concur with MCLs as ground water cleanup goals was based on technical and economic information in the Final FS for the GSA OU. The CVRWQCB stated "LLNL/DOE presented costs and time needed to clean up to MCLs and non-detectable TCE. Based on numerical fate and transport modeling, LLNL/DOE showed that concentrations of TCE would be below the limit of detection (0.5 ppb [µg/L) in all but a 12-acre area in the vicinity of the GSA after 55 years of pumping. The 12-acre area would be below the MCLs, except for an approximately 100 ft-square area at 5 to 10 ppb (µg/L. Simulation TCE fate and transport for an additional 35 years (without pumping) showed TCE contamination at or below 1 ppb ([µg/L) except for about a 100 ft-square area, which would be at or below the MCL. LLNL/DOE also simulate 90 years of pumping, which showed that TCE concentrations would be at or below 1 ppb (µg/L) in all locations. The Board agrees that 35 years of additional pumping for achieving the small amount of mass removal is not economically feasible. However, LLNL/DOE will be required to review the remedial system every five years to determine if the remedial objectives are being met. LLNL/DOE will optimize the system or propose an alternative remedial method if the plume is not being remediated as projected."

MCLs are health based and equivalent to an excess cancer risk of 10 -6, or one in one million, with consideration given to technologic and economic factors. U.S. EPA Region IX Preliminary Remediation Goals, according to EPA, "can be used as a rapid reference for screening concentrations in environmental media, as 'triggers' for further investigation at CERCLA/RCRA sites, and as initial cleanup goals, if applicable." The NCP (U.S. EPA, 1990a) states that "PRGs should be modified, as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected." Remediation goals are

developed by considering ARARs under Federal or State environmental laws. The NCP also states that the " 10 -6 risk level shall be used as the point-of-departure for determining remediation goals for alternatives when ARARs are not available."

3.2.2. General Comments

Comment 15:

Also, as a general comment, I would like to say that for each of the areas of Site 300, the DOE and the lab and the regulators would do well to interface with the DOE folks who are preparing the waste management programmatic environmental impact statement which gives as one of the potential alternatives, the burial of large amounts of ash from mixed waste and low level radioactive waste at Site 300 and how that potential burial of waste would impact the cleanup is something that they didn't look at in the waste management PEIS and that was one of our comments on that, but it's also something that you then can't incorporate in talking about the cleanup of these various operable units because, in fact, they didn't even mention where they planned to dump it at Site 300. So for each of these, that is a question for you guys to ask and get some clarification, and if you don't think dumping a lot of radioactive and still possibly toxic ash is going to aid the cleanup, you might have some allies in the citizens group on that.

Response to Comment No. 15:

Comment noted.

Comment 16:

One last overarching issue, and there is no delicate way to bring it up so I will just bring it up bluntly. Our group is really concerned about some of the changes that are being considered in the Superfund laws and in particular, some of the changes that would affect the Livermore lab cleanup wherein if the state standard was stricter than the federal standard, the federal standard would become the only thing that the lab would have to clean up to. There are a number of areas where the Regional Water Quality Control Board and the state DTSC have stricter standards than the federal EPA and achieving those standards is an important part of achieving an actual cleanup and so what I think should be investigated is the extent to which writing those things in the Record of Decision will be one way of protecting against having the standards be lowered as the cleanup goes on, and as we all know, once the standards change, the

Departments of Energy's target changes and so that target, in terms of how clean is clean and what they think they need to clean up to is in danger of becoming lower and lower and the Record of Decision is the method that I see to ensure that today's cleanup standards are the cleanup standard's that are met.

Response to Comment No. 16:

If Federal or State regulations were to change in the future, DOE and the regulatory agencies would discuss how these changes might affect cleanup. The community would be informed of any regulatory changes that affect cleanup at Site 300. Any proposed changes to the ROD must be submitted to the regulatory agencies for review and approval. Following EPA guidelines (U.S. EPA, 1991), the lead agency determines if the proposed ROD change is: 1) nonsignificant

or minor, 2) significant, or 3) fundamental. Community members would be informed of any ROD change, and would be provided with the opportunity to comment on significant or fundamental ROD changes. 0

Comment 17:

Our group has talked a number of times of the needfor stable long-term funding and budget commitments. Having some kind of budget schedule for the preferred alternative and any other alternative time scenarios would be very useful for citizens to be able to monitor the commitment of the DOE and the lab to the cleanup as well as in combination with achievement milestones and whether they are on track with that, whether the funding is adequate and so I would argue for some kind of additional information to be included on the budgetary aspect over time.

Response to Comment No. 17:

DOE cannot legally commit to funding cleanup or any other activities beyond the current budget year appropriation. However, DOE places a high priority on risk reduction, compliance, and associated environmental cleanup in its annual budget submittals. DOE understands that cleanup delays will likely increase the overall cost of the LLNL cleanup as well as other facilities, so it is in DOE's best interest to support an adequately funded and progressive cleanup effort through its annual Congressional budget request each year. DOE does commit to request from Congress, through the Office of Management and Budget, funding necessary to control and remediate contaminant plumes, both on and offsite. In addition, DOE is also committed to removing contaminants as efficiently as possible using available technologies within budgeting allocations.

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Figure

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Tables

Table 1. Contaminants of potential concern in ground water in the GSA.

Contaminant	Maximum concentration a	Mean concentration a,b	95% UCL a
Central GSA			
1,1,1-trichloroethane	2.0 x 10 3	2.93 x 10 -1	1.62 x 10 0
1,1-dichloroethylene	4.0 x 10 3	7.37 x 10 -1	1.18 x 10 0
cis-1,2-dichloroethylene c	1.0 x 10 3	2.56 x 10 0	3.75 x 10 0
Acetone	8.2 x 10 0	4.08 x 10 0	5.78 x 10 0
Benzene	5.0 x 10 1d		
Bromodichloromethane	3.3 x 10 0	4.05 x 10 -2	6.62 x 10 -2
Chloroform	7.4 x 10 0	6.10 x 10 -1	8.98 x 10 -1
Tetrachloroethylene	2.5 x 10 4	3.89 x 10 1	7.73 x 10 1
Trichloroethylene	2.4 x 10 5	8.30 x 10 2	3.09 x 10 3
Trichlorofluoromethane (Freon 113)	1.6 x 10 2	1.07 x 10 1	1.89 x 10 1
Eastern GSA			
1,1,1-trichloroethane	9.4 x 10 1	2.93 x 10 -1	1.62 x 10 0
1,1-dichloroethylene	5.0 x 10 -1	4.30 x 10 -1	4.45 x 10 -1
1,2-dichloroethylene c	6.0 x 10 -1	4.27 x 10 -1	4.41 x 10 -1
Bromodichloromethane	3.3 x 10 0	4.05 x 10 -2	6.62 x 10 -2
Chloroform	1.4 x 10 1	9.60 x 10 -1	4.25 x 10 0
Tetrachloroethylene	4.4 x 10 0	1.32 x 10 0	1.64 x 10 0
Trichloroethylene	6.1 x 10 1	2.66 x 10 1	3.39 x 10 1

a All units are in µg/L.

b Estimate of the arithmetic mean of the underlying log normal distribution.

c The chemical 1,2-dichloroethylene (1,2-DCE) exists as two isomers, cis-1,2-DCE and trans-1,2-DCE. At various times throughout the nine years of ground water analysis at Site 300, this chemical has been analyzed for as 1,2-DCE (total), as one or both of the specific isomers, or as all three. When concentration data were available for one or both isomers, we used those values and omitted the less specific analysis for

total 1,2-DCE from
further consideration. The exceptions to this were in cases where the concentration reported for total 1,2-DCE
was greater than that reported for one or both isomers.

d The value given for benzene is the maximum measured concentration for this chemical in ground water in the
central GSA. This maxima was reported from the last quarter of sampling data included in the SWRI database
(first quarter, 1992) (Webster-Scholton, 1994), and came from the vicinity of the Building 875 former dry wells.
A mean concentration and a 95% Upper Confidence Limit (UCL) were not calculated.

Table 2. Contaminants of potential concern in surface soil (0.5 ft) in the GSA.

Contaminant	Maximum concentration a	Mean concentration a,b	95% UCL a
1,1,1-trichloroethane	5.0 x 10 -3	6.85 x 10 -4	1.86 x 10 -3
Acetone	6.0 x 10 -2	3.39 x 10 -2	4.90 x 10 -2
Cadmium	1.6 x 10 1	6.43 x 10 0	9.31 x 10 0
Chloroform	3.0 x 10 -4	3.82 x 10 -4	8.75 x 10 -4
Copper	3.4 x 10 2	3.94 x 10 1	5.67 x 10 1
HMX	2.0 x 10 -2	NA c	2.0 x 10 -2c
Tetrachloroethylene	3.0 x 10 -2	1.61 x 10 -3	3.58 x 10 -3
Toluene	6.0 x 10 -3	1.30 x 10 -3	2.86 x 10 -3
Trichloroethylene	8.4 x 10 -2	3.75 x 10 -3	1.18 x 10 -2
Trichlorofluoromethane (Freon 113)	1.3 x 10 -2	1.00 x 10 -3	2.19 x 10 -3
Trichlorotrifluoroethane (Freon 11)	7.9 x 10 -2	1.23 x 10 -2	3.84 x 10 -2
Xylenes (total isomers)	7.0 x 10 -3	1.47 x 10 -3	3.40 x 10 -3
Zinc	8.3 x 10 2	2.06 x 10 2	3.62 x 10 2

a Units are mg/kg.

b Estimate of the arithmetic mean of the underlying log normal distribution.

c For certain data sets, calculation of an UCL yielded a value greater than the maximum measured concentration.
In those instances, a mean concentration was not calculated, and the maximum concentration is given instead
of a UCL.

Table 3. Contaminants of potential concern in subsurface soil (>0.5-12.0 ft) in the GSA.

Operable unit region	Contaminant	Maximum concentration a	Mean concentration a,b	95% UCL a
Building 875	1,1,1-trichloroethane	1.0 x 10 -2	2.13 x 10 -3	4.38 x 10 -3
	1,1-dichloroethylene	5.0 x 10 -4	NC c	5.0 x 10 -4c
	cis-1,2-dichloroethylene	3.0 x 10 -4	1.88 x 10 -4	2.96 x 10 -4
	Chloroform	3.0 x 10 -4	1.88 x 10 -4	2.96 x 10 -4
	Tetrachloroethylene	1.0 x 10 -1	3.28 x 10 -2	7.54 x 101 -2
	Trichloroethylene	5.4 x 10 -1	1.74 x 10 -1	4.14 x 10 -1
	Trichlorotrifluoroethane (Freon 11)	6.0 x 10 -2	8.03 x 10 -3	1.87 x 10 -2
Debris burial trenches	Chloroform	4.3 x 10 -2	1.47 x 10 -3	3.35 x 10 -3
	Methylene chloride	1.4 x 10 -2	4.26 x 10 -4	1.74 x 10 -3
	Tetrachloroethylene	8.8 x 10 -3	1.95 x 10 -3	4.32 x 10 -3
	Toluene	5.0 x 10 -3	2.73 x 10 -3	3.14 x 10 -3
	Trichloroethylene	2.4 x 10 -2	2.43 x 10 -3	4.31 x 10 -3
	Trichlorofluoromethane (Freon 113)	3.3 x 10 -3	1.34 x 10 -4	3.95 x 10 -4
	Trichlorotrifluoroethane (Freon 11)	4.0 x 10 -4	1.20 x 10 -4	1.67 x 10 -4

a Units are mg/kg.

b Estimate of the arithmetic mean of the underlying log normal distribution.

c NC = Not calculated. For certain data sets, calculation of a UCL yielded a value greater than the maximum measured concentration (Webster-Scholten, 1994, Appendix P). In those instances, a mean concentration was not calculated, and the maximum concentration is given instead of a UCL.

Table 4. Contaminants of potential concern in VOC soil flux in the GSA.

Contaminant	Limit of detection (mg/m 2•s)	Maximum emission rate (mg/m 2•s)	Mean emission rate a (mg/m 2•s)	95% UCL of emission rate (mg/m 2•s)
Central GSA				
1,2,4-trimethylbenzene	1.05 x 10 -6	9.19 x 10 -6	1.25 x 10 -6	2.00 x 10 -6
1,3,5-trimethylbenzene	1.10 x 10 -6	2.00 x 10 -6	NA b	2.10 x 10 -6
Benzene	6.79 x 10 -7	2.39 x 10 -5	1.73 x 10 -6	3.64 x 10 -6
Methylene chloride	9.50 x 10 -7	5.20 x 10 -5	4.36 x 10 -6	1.69 x 10 -5
Toluene	8.01 x 10 -7	3.59 x 10 -6	1.03 x 10 -6	1.37 x 10 -6
Trichloroethylene	1.13 x 10 -6	3.73 x 10 -6	3.33 x 10 -7	1.11 x 10 -6
Trichlorotrifluoroethane (Freon 113)	1.70 x 10 -6	3.88 x 10 -4	7.49 x 10 -5	2.22 x 10 -4
m- and p-xylenes	9.58 x 10 -7	5.27 x 10 -6	1.11 x 10 -6	1.97 x 10 -6
o-xylenes	9.58 x 10 -7	2.43 x 10 -6	5.15 x 10 -7	9.35 x 10 -7
Eastern GSA				
1,1,1-trichloroethane	1.18 x 10 -6	1.32 x 10 -6	1.11 x 10 -6	1.32 x 10 -3
1,2,4-trichlorobenzene	1.09 x 10 -6	2.11 x 10 -6	1.11 x 10 -6	1.36 x 10 -6

Dichlorodifluoromethane (Freon 12)	1.09 x 10 -6	2.45 x 10 -6	6.48 x 10 -7	1.12 x 10 -6
Methylene chloride	8.67 x 10 -7	6.06 x 10 -5	7.63 x 10 -6	3.52 x 10 -5
Styrene	9.07 x 10 -7	1.42 x 10 -6	4.90 x 10 -7	1.01 x 10 -6
Toluene	8.34 x 10 -7	1.67 x 10 -6	1.10 x 10 -6	1.27 x 10 -6
Trichloroethylene	1.18 x 10 -6	1.77 x 10 -6	6.89 x 10 -7	1.35 x 10 -6
Trichlorotrifluoroethane (Freon 113)	1.77 x 10 -5	5.67 x 10 -5	3.40 x 10 -5	4.06 x 10 -5
m- and p-xylenes	9.98 x 10 -7	2.87 x 10 -6	1.32 x 10 -6	1.63 x 10 -6
o-xylenes	9.98 x 10 -7	1.45 x 10 -6	6.13 x 10 -7	1.16 x 10 -6
Building 875 dry well area				
1,2,4-trimethylbenzene	1.09 x 10 -6	3.89 x 10 -6	1.09 x 10 -6	1.98 x 10 -6
Chloromethane	4.63 x 10 -7	1.12 x 10 -6	1.87 x 10 -7	4.38 x 10 -7
Dichlorodifluoromethane (Freon 12)	1.09 x 10 -6	1.10 x 10 -6	NA b	1.10 x 10 -6
Ethylbenzene	9.98 x 10 -7	4.49 x 10 -6	8.77 x 10 -7	1.41 x 10 -6
Methylene chloride	7.71 x 10 -7	2.02 x 10 -5	6.37 x 10 -6	1.14 x 10 -5
Tetrachloroethylene	1.54 x 10 -6	2.20 x 10 -6	1.02 x 10 -6	1.83 x 10 -6
Toluene	8.34 x 10 -7	1.05 x 10 -5	1.55 x 10 -6	2.97 x 10 -6
Trichloroethylene	1.18 x 10 -6	1.68 x 10 -5	3.01 x 10 -6	1.13 x 10 -5

Table 4. (Continued)

Contaminant	Limit of detection (mg/m 2•s)	Maximum emission rate (mg/m 2•s)	Mean emission rate a (mg/m 2•s)	95% UCL of emission rate (mg/m 2•s)
Building 875 dry well area (Continued)				
Trichlorotrifluoroethane (Freon 113)	1.82 x 10 -6	8.06 x 10 -5	2.86 x 10 -5	3.96 x 10 -5
m- and p-xylenes	9.98 x 10 -7	1.83 x 10 -5	2.98 x 10 -6	1.30 x 10 -5
o-xylenes	9.98 x 10 -7	3.37 x 10 -6	7.03 x 10 -7	1.39 x 10 -6

a Estimate of the arithmetic mean of the underlying log normal distribution.

b For certain data sets, calculation of an UCL yielded a value greater than the maximum measured concentration.
In those instances, a mean concentration was not calculated, and the maximum concentration is given instead of a UCL.

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Table 6. (Continued)

Potential exposure pathway	Additive incremental excess lifetime cancer risk estimate	Additive hazard index	Location of related tables in supporting documents

Adult Onsite Exposure in the GSA	9 x 10 -7	9.8 x 10 -3

FS:

Table 1-37

SWRI (Chapter 6):

Table 6-55

Potential residential exposure to contaminated ground water

FS:

that originates in the GSA at:

Table 1-26

a) Central GSA site boundary	a) 7 x 10 -2	a) 5.6 x 10 2

SWRI (Appendix P):

b) Eastern GSA site boundary	b) 5 x 10 -5	b) 5.0 x 10 -1

Tables P-27-6.5

c) Well CDF-1	c) 1 x 10 -5	c) 1.4 x 10 -1

P-27-6.6

d) Well SR-1	d) 2 x 10 -5	d) 1.6 x 10 -1

P-27-6.7

P-27-6-8

P-27-6.13

P-27-6.14

P-27-6.15

P-27-6.16

Notes:
AOS = Adult Onsite.
FS - Final Feasibility Study for the General Services Area, LLNL Site 300 (Rueth and Berry, 1995).
GSA = General Services Area.
SWRI = Final Site-Wide Remedial Investigation Report, LLNL Site 300 (Webster-Scholten, 1994).
VOC = Volatile Organic Compound.

Table 6. Cancer risk and hazard index summary, and reference list for the GSA OU.

Potential exposure pathway	References for related tables in supporting documents	Additive incremental excess lifetime cancer risk estimate	Additive hazard index
Inhalation of VOCs that volatilize from soil to outdoor air in the		2 x 10 -7	

6.2 x 10 -3 FS:
vicinity of the Building 875 dry well area in the central GSA
Tables 1-28
(AOS exposure)
1-31

1-34
Inhalation of VOCs that volatilize from soil to outdoor air in the 7 x 10 -7
1.2 x 10 -3 FS:
vicinity of the central GSA (AOS exposure)
Tables 1-29

1-32

1-35
Inhalation of VOCs that volatilize from soil to outdoor air in the 2 x 10 -7
1.3 x 10 -3 FS:
vicinity of the eastern GSA (AOS exposure)
Tables 1-30

1-33

1-36
Inhalation of VOCs that volatilize from subsurface soil into the 1 x 10 -5
3.0 x 10 -1 SWRI (Chapter 6):
indoor air of Building 875 in the central GSA (AOS exposure)
Table 6-51

Appendix P

Tables P-27-6.1

P-27-6-10
Potential AOS exposure to contaminants in, surface soil (0 to
FS:
0.5 ft) in the GSA for:
Table 1-25

SWRI (Appendix P):
a) inhalation of particulates resuspended from surface soil, and a) 2 x 10 -7
a) 5.6 x 10 -5 Tables P-27-6
b) ingestion and dermal adsorption to surface soil b) 2 x 10 -10
b) 8.5 x 10 -3 a) P-27-6.11

b) P-27-6.12

Table 7. Summary of GSA OU remedial alternatives.

Alternative 1: No action	• Monitoring - Quarterly water level measurements of monitor wells and supply wells. - Periodic ground water sampling and analysis of monitor wells and supply wells. - QA/QC samples.

	• Administrative controls - Fencing and warning signs around site. - Full-time security guards on site. • Continued ecological surveys. Other - Well and pump maintenance. - Reporting. - Project management. - Database management. - QA/QC review. Modeled project life: 80 years of ground water monitoring to reach MCLs.
Alternative 2: Exposure control offsite water-supply wells CDF-1, CON-1, and SR-1 if VOC concentrations exceed MCLs.	All elements of Alternative 1 plus: • Contingency POU treatment - Install and operate POU GAC treatment system for Modeled project life: 80 years of ground water monitoring to reach MCLs.
Alternative 3a: Remediation and protection of the Tnbs 1 regional aquifer	All elements of Alternative 2 plus: . Ground water extraction well installation - Install four new ground water extraction wells. - Convert six existing monitor wells to ground water extraction wells and one to an injection well. • Ground water extraction and treatment - Extract ground water from 20 extraction wells (19 shallow alluvial, 1 Tnbs 1 regional) and reinject into 1 well (Tnbs 1 regional). - Install new ground water treatment systems using air stripping, VOC adsorption, and/or other appropriate technologies. Design capacity would be approximately 15+ gpm at the central GSA and 46+ gpm at the eastern GSA. - Extract ground water from Tnbs 1 regional aquifer until VOC concentrations reach MCLs. - Extract ground water from the alluvial aquifer until ground water VOC concentrations are reduced to levels protective of the Tnbs 1 regional aquifer (approximately 100 µg/L).

Table 7. (Continued)

	• Soil vapor extraction (SVE) and treatment - SVE from seven existing wells. - SVE and treatment using existing system until vapor concentrations reach levels that prevent recontamination of ground water above MCLs, and to reduce inhalation risk in Building 875. • Other - Permitting. - Ground water treatment system and SVE system maintenance. Project life: 10 years of SVE, 10 years of ground water extraction and treatment at the eastern GSA and 30 years at the central GSA, and 70 years of ground water monitoring to reach MCLs.
Alternative 3b: Ground water plume remediation	All elements of Alternative 3a plus: • Continued ground water extraction and treatment at the central GSA until ground water VOC concentrations are reduced to MCLs. Project life: 10 years of SVE, 10 years of ground water extraction and treatment at the eastern GSA and 55 years at the central GSA, and 60 years of ground water monitoring to reach MCLs.

Table 8. Comparative evaluation of remedial alternatives for the GSA OU.

Alternative	Overall protection of human health and environment	Reduction in Long-term effectiveness and permanence	Compliance with ARARs	Short-term effectiveness	Implementability	Cost a,b
Alternative 1 No action	Human health: No Environment: No	Criterion may be met c	Dependent on natural attenuation and degradation.	Protective of site workers and the community during monitoring by preventing potential exposure through the use of administrative controls and/or use of protective equipment. Ground water and air risks not addressed.	Implementable	3.47 Not effective.

Alternative 2 Effective for ground water risks at existing control reduction of VOC or air risk	Human health: Exposure Air Ground water: Environment:	Dependent on natural attenuation and degradation. No Yes d No	Criterion may be met c	Protective of site workers and the community during exposure through the use of administrative controls and/or use of protective equipment. Addresses ground water risk with POU treatment at existing water-supply wells. Does not address air risk.	Implementable 3.69 term mass
Alternative 3a Effective for air and Remediation and protection of Tnbs 1 aquifer. May not be effective for the regional water risk in aquifer	Human health: Air: Yes Ground water: Yes Environment: Yes	Reduction in shallow unsaturated zone, and shallow and deep aquifer contamination; partially dependent on natural attenuation and degradation.	Criterion may be met	Protective of site workers and the community during remedial action by preventing potential exposure through the use of administrative controls and/or use of protective equipment. Addresses site risks with active remediation of soil and ground water.	Implementable 17.17 ground water risk in shallow aquifer in the central GSA. Ground water and soil vapor extraction increases source removal effectiveness.

Table 8. (Continued)

	Overall protection of human health and environment	Reduction in contaminant volume,	Compliance	Short-term effectiveness and	Long-term

Alternative	environment	with ARARs	effectiveness
permanence	toxicity, and mobility	Implementability	Cost a,b
Alternative for air and 3b water risks. Ground water and soil extraction remediation soil and of both water shallow and contamination. regional aquifers	Human health: Reduction in shallow Air Yes unsaturated zone, Ground water: Yes and shallow and deep aquifer Environment: Yes contamination.	Criterion met Implementable	Protective of site workers 18.90 and the community during remedial action by preventing potential exposure through the use of administrative controls and/or use of protective equipment. Addresses site risks with active remediation of soil and ground water.	Effective ground Ground vapor address all ground

a Estimated total present worth in millions of 1995 dollars. Overall cost is highly dependent on the required length of pumping time.
b The estimated costs for all alternatives presented in this ROD are slightly lower than the costs presented in the GSA FS and PP. This is due to modifications to the 1) contingency POU treatment component based on negotiations with the well owner, and 2) ground water monitoring component based on changes made to the eastern and central GSA treatment facility permit monitoring program requirements.
c Relies solely on natural attenuation and degradation to comply with Safe Drinking Water Act, Basin Plan, and State Resolutions 68-16 and 92-49.
d Protective of human health for ingestion of ground water from existing water-supply wells.

Table 9. Chemical-specific ARARs for potential chemicals of concern in ground water at the GSA OU.

Chemical of concern	Cancer group a	Federal MCL (µg/L)	State MCL (µg/L)
1,1,1-trichloroethane	D	200	200
1,1-dichloroethylene	C	7	6
cis-1,2-dichloroethylene	D	70	6
Benzene	A	5	1
Bromodichloromethane	B2	100 b	100b
Chloroform	B2	100 b	100b
Tetrachloroethylene	B2-C	5	5
Trichloroethylene	B2-C	5	5

a Integrated Risk Information System (IRIS) database maintained by the U.S. EPA.
U.S. EPA cancer group:
A = Known carcinogen.
B2 = Probable carcinogen.
C = Possible carcinogen.
D = Noncarcinogen.
b Total trihalomethanes.

NA = Not available.
µg/L = Micrograms per liter.

Table 10. Selected remedy (Alternative 3b): Capital costs for source mass removal and plume migration prevention in the GSA OU.

	Quantity	Unit type	Unit price (1995 $)	Total (1995 $)
Capital costs				
Central GSA				
Ground water and soil vapor extraction system major equipment costs (MEC)				
Wellhead vaults, valves, sampling ports, gauges	7 previously installed			
Additional wellhead vaults, valves, sampling ports, gauges	10	each	1,500	15,000
Electrical line and conduit	1,200	foot	1.75	2,100
2-in. polyvinyl chloride (PVC) piping	1,200	foot	1.50	1,800
Electric submersible pumps (1 /2 horse power [hp])	10 previously installed			
Additional electric submersible pumps (1/2 hp)	10	each	800	8,000
PVC pipe fittings, unistrut	1	lot	10,000	10,000
SVE blower system (5 hp)	1	each	2,000	2,000
SVE pitot tubes, vacuum gauges, sampling ports	Previously installed			
SVE treatment MEC				
Moisture accumulation assembly, carbon canister hookup	Previously installed			
Vapor-phase carbon canisters (1,000 lb)	3	each	6,000	18,000
SVE manifold, piping	Previously installed			
Ground water treatment MEC				

Particulate filter assembly	1	each	3,700	3,700
Low-profile tray air stripper (includes blower and transfer pumps, total of 7 hp)	1	each	20,000	20,000
Carbon dioxide injection equipment	1	each	1,500	1,500
Discharge storage tank (20,000 gal.)	Previously installed			
Discharge pump (15 hp)	Previously installed			
Moisture accumulation assembly, carbon canister hookup	1	each	1,100	1,100
Air heater (700 W)	1	each	500	500
Vapor-phase carbon canisters (140 lb)	Previously installed			
Manifold, piping, valves, gauges, sampling ports, totalizer, controllers	1	lot	15,000	15,000
Discharge piping and fittings	Previously installed			

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 $)	Total (1995 $)
Eastern GSA				
Ground water extraction and treatment system MEC				
Wellhead vaults, valves, sampling ports, gauges	3 previously installed			
Electrical line and conduit	Previously installed			
Electric submersible pumps (1/2 hp)	3 previously installed			
2-in. PVC piping	Previously installed			
PVC pipe fittings, unistrut	Previously installed			
Particulate filter assembly	1	each	3,700	3,700
Low-profile tray air stripper (includes blower and transfer pumps, total of 7 hp)	1	each	20,000	

20,000				
Moisture accumulation assembly, carbon canister hookup	1	each	1,100	1,100
Vapor-phase carbon canisters (140 lb)	Previously installed			
Manifold, piping, valves, gauges, sampling ports, totalizer, controllers	Previously installed			
Discharge piping and fittings	Previously installed			
Total MEC for eastern GSA ground water treatment system				
24,800				
Total MEC for GSA ground water extraction and SVE treatment systems				
123,500				
Electrical components (20% of MEC)				
24,700				
Installation cost (58% of MEC)				
71,630				
Major equipment installed cost (MEIC)				
219,830				
	Other capital costs			
Wells/borings				
Ground water extraction well installation and development	4	well	10,000	40,000
Piezometer installation and development	10	well	10,000	100,000
Soil boring and initial water sample analyses	14	well	1,500	21,000
Soil disposal (Class III)	35	cu yard	20	700
Hydraulic test for ground water extraction wells	10	well	3,000	30,000
Hydraulic test for reinjection well	1	well	5,000	5,000
Hydraulic test for piezometers	10	well	1,500	15,000
Structures				

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 $)	Total (1995 $)
Equipment building for central GSA SVE treatment system	1	each	300,000	300,000
Equipment building for central GSA ground water treatment system	1	each	300,000	300,000
Equipment building for eastern GSA ground water treatment system	1	each	300,000	300,000
Geotechnical testing	3	each	20,000	60,000
Contingency POU ground water treatment system for offsite water-supply wells CDF-1, CON-1, and SR-1				
Wellhead modification	3	each	1,000	3,000
Particulate filter	3	each	2,000	6,000
Aqueous-phase carbon beds (1,000 lb)	6	each	6,000	36,000
Double-containment skid (8'x 15')	3	each	4,000	12,000
System plumbing, totalizer, fittings	3	lot	2,000	6,000
Total field costs (TFC)				1,454,530
Professional environmental services				
Design/assist with project management				50,000
Permitting				50,000
Start-up labor and analyses				60,000
SVE performance evaluation				25,000
Total professional environmental services				185,000

LLNL tax (11% of total field costs and professional environmental services)
180,348

LLNL Environmental Restoration Division (ERD) team

Full-time employee (FTE) 3 FTE
180,000 540,000

Remedial Design Report
300,000

Total LLNL ERD team
840,000

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 $)	Total (1995 $)
LLNL technical support services				
LLNL Plant Engineering planning and Title I, II, and III services	5	FTE	180,000	900,000
Total LLNL support services				900,000
Total capital costs				3,559,878

Operation and maintenance (O&M) costs

Fixed O&M costs for soil vapor and ground water extraction and treatment

Fixed annual O&M costs for SVE				
Electricity	30,000	kw·h	0.07	2,100
Electrical capacity charge	3.7	kw	36	133
SVE air sampling analysis	12	event	560	6,720

Maintenance materials (10% of total installed MEC)
8,200

LLNL tax (11% of outside charges)
1,887

Project management 0.15 FTE
238,500 35,775

System optimization, engineer 0.20 FTE
173,500 34,700

Well field optimization, hydrogeologist 0.10 FTE
173,500 17,350

Operating labor 0.30 FTE
129,800 38,940

Clerical 0.10 FTE
92,600 9,260

Maintenance labor (15% of total installation cost)
7,134

Total fixed annual SVE O&M costs
162,199

Total present worth of fixed O&M for soil vapor extraction, years 1-10 (factor = 8.317)
1,349,010

Fixed annual ground water extraction and treatment O&M for central GSA

Electricity 170,000 kw·h
0.07 11,900

Electrical capacity charge 21.6 kw
36 776

Scale prevention/recarbonation 4,000 lb CO2
0.60 2,400

Ground water treatment system air sampling analysis 12 event
560 6,720

Ground water treatment system analyses (water only) 12 event
200 2,400

Maintenance materials (10% of total installed MEC)
16,300

LLNL tax (11% of outside charges)
4,455

Project management 0.10 FTE
238,500 23,850

System optimization, engineer 0.15 FTE
173,500 26,025

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 $)	Total (1995 $)
Well field optimization, hydrogeologist	0.15	FTE	173,500	26,025
Operating labor	0.30	FTE	129,800	38,940
Clerical	0.10	FTE	92,600	9,260
Maintenance labor (15% of total installation cost)				14,181
Total fixed annual ground water extraction and treatment O&M for central GSA				183,232
Total present worth of annual ground water treatment O&M for central GSA, years 1-55 (factor = 24.264)				4,445,937
Fixed annual ground water extraction and treatment O&M for eastern GSA				
Electricity	60,000	kw·h	0.07	4,200
Electrical capacity charge	7.6	kw	36	274
Scale prevention/recarbonation	12,000	lb CO_2	0.60	7,200
Ground water treatment system air sampling analysis	12	event	560	6,720
Ground water treatment system analyses (water only)	12	event	200	2,400
Maintenance materials (10% of total installed MEC)				10,000
LLNL tax (11% of outside charges)				3,387
Project management	0.10	FTE	238,500	23,850
System optimization, engineer	0.15	FTE	173,500	26,025

Well field optimization, hydrogeologist		0.15	FTE	
173,500	26,025			
Operating labor		0.30	FTE	
129,800	38,940			
Clerical		0.10	FTE	
92,600	9,260			
Maintenance labor (15% of total installation cost)				
8,700				
Total fixed annual ground water extraction and treatment O&M for eastern GSA				
166,981				
Total present worth of annual ground water treatment O&M for eastern GSA, years 1-10 (factor = 8.327)				
1,390,453				
Total present worth of fixed O&M costs for 55 years				
7,185,400				

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 $)	Total (1995 $)
Variable operating costs for soil vapor and ground water extraction and treatment				
Annual costs, year 1				
SVE replacement of GAC	3,950	lb	2.30	9,085
Ground water treatment system replacement of vapor phase GAC	650	lb	2.30	1,495
Total annual costs, year 1				10,580
Total present worth, year 1 (factor = 0.966)				10,220
Annual costs, year 2				
SVE replacement of GAC	980	lb	2.30	2,254
Ground water treatment system replacement of vapor phase GAC	650	lb	2.30	1,495
Total annual costs, year 2				3,749
Total present worth, year 2 (factor = 0.934)				3,502

Annual costs, year 3				
SVE replacement of GAC	490	lb	2.30	1,127
Ground water treatment system replacement of vapor phase GAC	650	lb	2.30	1,495
Total annual costs, year 3				2,622
Total present worth, year 3 (factor = 0.902)				2,365
Annual costs, year 4				
SVE replacement of GAC	125	lb	2.30	288
Ground water treatment system replacement of vapor phase GAC	650	lb	2.30	1,495
Total annual costs, year 4				1,783
Total present worth, year 4 (factor = 0.871)				1,553
Annual costs, year 5				
SVE replacement of GAC	60	lb	2.30	138
Ground water treatment system replacement of vapor GAC	650	lb	2.30	1,495
Total annual costs, year 5				1,633
Total present worth, year 5 (factor = 0.842)				1,375
Annual costs, years 6-10				

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 $)	Total (1995 $)
SVE replacement of GAC	5	lb	2.30	12
Ground water treatment system replacement of vapor phase GAC	325	lb	2.30	748
Total annual costs, years 6-10				759
Total present worth, years 6-10 (factor = 3.801)				2,885
Annual costs, years 11-30				
Ground water treatment system replacement of vapor				

phase GAC 75 lb
2.30 173

Total annual costs, years 11-30
173

Total present worth, years 11-30 (factor = 10.075)
1,738

Annual costs, years 31-55

Ground water treatment system replacement of vapor phase GAC 5 lb
2.30 12

Total annual costs, years 31-55
12

Total present worth, years 31-55 (factor = 5.872)
68

Total present worth of variable operating costs for soil vapor and ground water extraction and treatment
23,705

Ground water and soil vapor monitoring

Annual costs, years 1-10

SVE vapor VOC analysis 84 each
110 9,240

VOC analysis (EPA Method 601) 206 each
50 10,300

VOC analysis (EPA Method 602) 12 each
50 600

Annual spring water sample analyses 3 suite
545 1,635

QA/QC analyses (10% of analytic costs)
2,178

Quarterly monitoring reports 4 report
15,000 60,000

LLNL tax (11% of outside charges)
9,235

Monthly SVE vapor sample collection 7 well
375 2,625

Quarterly water level measurements (including 10 piezometers) 111 well
62.50 6,938

Quarterly ground water sample collection 7 well
500 3,500

Semiannual ground water sample collection	89	well	250	2,250
Annual ground water sample collection	12	well	125	1,500
Annual spring water sample collection	3	spring	125	375
Maintenance of ground water sampling system	101	well	430	43,430

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 $)	Total (1995 $)
Project management	0.35	FTE	238,500	83,475
Total annual costs, years 1-10				257,280
Total present worth, years 1-10 years (factor = 8.317)				2,139,796
Annual costs, years 11-55				
VOC analysis (EPA Method 8010)	128	each	50	6,400
VOC analysis (EPA Method 8020)	12	each	50	600
Annual spring water sample analyses	3	suite	545	1,635
QA/QC analyses (10% of analytic costs)				864
Annual monitoring report	1	report	15,000	15,000
LLNL tax (11% of outside charges)				2,695
Quarterly water level measurements (including 10 piezometers)	111	well	62.50	6,938
Semiannual ground water sample collection	39	well	250	9,750

Annual ground water sample collection	50	well	125	6,250
Annual spring water sample collection	3	spring	125	375
Maintenance of ground water sampling system	91	well	430	39,130
Project management	0.35	FTE	238,500	83,475
Total annual costs, years 11-55			173,111	
Total present worth, years (factor=15.947)			2,760,598	
Annual costs, years 56-60				
VOC analysis (EPA Method 601)	111	each	50	5,550
VOC analysis (EPA Method 602)	12	each	50	600
Annual spring water sample analyses	3	suite	545	1,635
QA/QC analyses (10% of analytic costs)			779	
Annual monitoring report	1	report	15,000	15,000
LLNL tax (11% of outside charges)			2,592	
Quarterly water level measurements (including 10 piezometers)	111	well	62.50	6,938
Semiannual ground water sample collection	37	well	250	9,250
Annual ground water sample collection	37	well	125	4,625

Table 10. (Continued)

	Quantity	Unit type	Unit price (1995 $)	Total (1995 $)

Annual spring water sample collection	3	spring	125	375
Manintenance of ground water sampling system	74	well	430	31,820
Project management	0.15	FTE	238,500	35,775
Total annual costs, years 56-60			114,938	
Total present worth, years 56-60 years (factor = 0.681)			78,273	
Total present worth of ground water and soil vapor monitoring for 60 years (5 years after reaching MCLs)			4,978,667	
Contingency costs and totals				
Subtotal present worth of Alternative 3b			15,747,651	
Contingency (20%)			3,149,530	
Total present worth of Alternative 3b				18,897,181

Table 11. ARARs for the selected remedy at the GSA OU.

Action	Source	Description	Application to the selected remedy
Ground water extraction treatment standards setting MCLs	Federal: Safe Drinking Water [42 USCA 300 and 40 CFR 141.11-141.16, 141.50-141.51]	As part of the selected remedy, VOC concentrations will be reduced to MCLs in all ground water in the GSA OU. (Applicable: Chemical-specific)	Establishes potential drinking water sources by and non-zero Maximum Contaminant Level Goals (MCLGs), which are used as cleanup standards. Those standards for the GSA OU are listed in Table 9 of

the ROD.

		State:	
of	All cleanup activities associated	State Water Resources Control Board (SWRCB) Resolution 92-49	Requires oversight
cleanup and	with implementation of the	(Applicable: Chemical-specific)	investigations and
resulting	selected remedy will be		abatement activities
waste that	conducted under the supervision		from discharges of
water quality.	of the CVRWQCB.		affect or threaten
		Cal. Safe Drinking Water	
treatment standards	As part of the selected remedy,	[California Health and Safety	Establishes
potential drinking	concentrations will be reduced to	Code Section 116365]	for current
setting MCLs	MCLs in all ground water in the	(Applicable: Chemical-specific)	water sources by
cleanup	GSA OU.		which are used as
standards for			standards. Those
listed in Table 9			the GSA OU are
			of the ROD.
		Chapter 15, Code of California	
of the	During and after completion of	Regulations (CCR), Title 23,	Requires monitoring
remedial	the selected remedy,	Sections 2550.7, 2550.10	effectiveness of the
concentrations of VOCs in in situ		(Applicable: Chemical-specific)	actions.
ground water will be measured.			

Table 11. (Continued)

Action	Description	Source	Application to the selected remedy
Ground water extraction (cont.)		State: (cont.)	
		Water Quality Control Plan	
beneficial uses and	As part of the selected remedy,	(Basin Plan) for CVRWQCB	Establishes
objectives for	VOC concentrations in ground		water quality
surface waters	water will be remediated to	(Applicable: Chemical-specific)	ground water and
Valley Region as	levels listed in Table 9.		in the Central
implementation plans to			well as
			meet water quality

objectives and uses.			protect beneficial
		SWRCB Resolution 88-63	Designates all
ground and	As part of the selected remedy,		
the State as	VOC concentrations will be	(Applicable: Chemical-specific)	drinking water
sources with	reduced to levels protective of		specific exceptions.
drinking water beneficial use as described in Section 2.10.1.			
Soil vapor extraction		State:	
		Water Quality Control Plan	Establishes
beneficial uses and	As part of the selected remedy,	(Basin Plan) for CVRWQCB	water quality
objectives for	VOC concentrations in soil vapor		ground water and
surface waters	will be remediated to levels	(Applicable: Chemical-specific)	in the Central
Valley Region, as	protective of ground water		well as
implementation plans to	(MCLs).		meet water quality
objectives and uses.			protect beneficial
		Chapter 15, CCR, Title 23,	Requires monitoring
of the	During and after completion of	Sections 2550.7, 2550.10	effectiveness of the
remedial	the selected remedy,		actions.
concentrations of contaminants in in situ vapor will be measured.		(Applicable: Chemical-specific)	

Table 11. (Continued)

Action	Description	Application to the selected remedy	Source
Contingency POU treatment at water-supply wells		State:	
		Cal. Safe Drinking Water Act	Establishes
chemical-specific	As part of the selected remedy,	(California Health and Safety	standards for public
drinking	VOC concentrations will be	Code Section 116365)	water systems by

setting MCL	reduced to MCLs by POU		goals.
treatment at existing water-supply wells, if necessary.		(Applicable: Chemical-specific)	
		SWRCB Resolution 92-49	Requires oversight
of cleanup and resulting waste that water quality.	All cleanup activities associated with implementation of the selected remedy will be conducted with oversight by the CVRWQCB.	(Applicable: Chemical-specific)	investigations and abatement activities from discharges of affect or threaten
Treated ground water discharge		State:	
		SWRCB Resolution 68-16	Requires that high
quality water be maximum	In the context of the selected remedy, this is applicable to the discharges of treated ground	(Anti-degradation policy)	surface and ground maintained to the extent possible.
water. The eastern GSA ground water treatment system (GWTS) discharges treated water to Corral Hollow Creek under the requirements of the current NPDES permit issued by the CVRWQCB. The central GSA GWTS discharges to bedrock in an onsite canyon under the requirements of the current Substantive Requirements issued by the CVRWQCB.		(Applicable: Chemical-specific)	

Table 11. (Continued)

Action	Description	Source	Application to the selected remedy

Treated ground water reinjection for treated water.	During the selected remedy, treated ground water would be analyzed to verify complete removal of VOCs to regulatory treatment standards, prior to reinjection.	Federal: Safe Drinking Water Act Underground Injection Control Program (40 CFR 144.26-124.27) (Applicable: Action-specific)	Requires monitoring reinjection of
		SWRCB Resolution 68-16 (Anti-degradation policy) (Applicable: Chemical-specific)	Requires that high surface and ground water be maintained to the maximum extent possible.
Treated soil vapor discharge nonvehicular sources	During the selected remedy, contaminated soil vapor will be treated with GAC, or equivalent technologies, and discharged to the atmosphere. The compliance standards for treated soil vapor are contained in the current Authority to Construct and subsequent Permit to Operate issued by the SJVUAPCD.	Local: San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) Rules and Regulations, Rules 463.5 and 2201 (Applicable: Chemical-specific)	Regulates of air contaminants.
Disposition of hazardous waste wastes from through transportation, and ultimate	For the selected remedy, this ARAR applies primarily to the spent GAC vessels.	State: Health and Safety Code, Sections 25100-25395, CCR, Title 22, Ch. 30: Minimum Standards for Management of Hazardous and Extremely Hazardous Wastes (Applicable: Action-specific)	Controls hazardous point of generation accumulation, treatment, storage, disposal.

Table 11. (Continued)

Action	Description	Source	Application to the selected remedy
Protection of endangered species facilities or contribute to the taking of any endangered or threatened species of plants, fish, or wildlife.	Prior to facility construction, or similar potentially disruptive activities, wildlife surveys will be conducted and mitigation measures implemented if required.	Federal: Endangered Species Act of 1973, 16 USC Section 1531 et seq. 50 CFR Part 200, 50 CFR Part 402 [40 CFR 257.3-2] (Applicable: Location-specific) State: California Endangered Species Act, California Department of Fish and Game Sections 2050-2068 (Applicable: Location-specific)	Requires that practices not cause NEPA implementation requirements may apply.
Floodplain protection facilities must be designed, constructed, operated, and maintained to prevent washout of any hazardous waste by a 100-year flood.	If it becomes necessary to install point-of-use treatment for water-supply wells CDF-1 or CON-1, which are located offsite within the 100-year floodplain, the POU systems would be constructed in accordance with this requirement.	State: 22 CCR 66264.18 (B)(1) (Applicable: Location-specific)	Requires that TSD within a 100-year

Acronyms and Abbreviations

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AOS	Adult Onsite
ARARs	Applicable or Relevant and Appropriate Requirements
Cal EPA	State of California, Environmental Protection Agency
CARE	Citizens Against a Radioactive Environment
CCR	Code of California Regulations
CDF	California Department of Forestry
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
CMB	Claystone Marker Bed
CPF	Cancer Potency Factor
CVRWQCB	Central Valley Regional Water Quality Control Board
DCE	Dichloroethylene
DNAPLs	Dense Nonaqueous Phase Liquids
DOE	Department of Energy
DTSC	California Department of Toxic Substances Control
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division
FFA	Federal Facility Agreement
FS	Feasibility Study
FTE	Full Time Employee
GAC	Granular Activated Carbon
gal	Gallons
gpm	Gallons per minute
GSA	General Services Area

GWTS	Ground Water Treatment System
HE	High Explosives
HI	Hazard Index
hp	Horsepower
HQ	Hazard Quotient
HMX	Cyclotetramethylenetetranitramine
IRIS	Integrated Risk Information System

LLNL	Lawrence Livermore National Laboratory
MCLs	Maximum Contaminant Levels
MEC	Major Equipment Cost
MEIC	Major Equipment Installed Cost
mg/kg	Milligrams per kilogram
mg/L	Micrograms per liter
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NPDES	National Pollutant Discharge Elimination System
O&M	Operation and Maintenance
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PCE	Tetrachloroethylene
PEFs	Pathway Exposure Factors
POU	Point of Use
ppb v/v	Parts per billion on a volume-to-volume basis. Also referred to as ppb v.
PRGs	Preliminary Remediation Goals
PVC	Polyvinyl Chloride
QA	Quality Assurance
Qal	Quaternary alluvial deposits
QC	Quality Control

Qt	Quaternary terrace deposits
RAOs	Remedial Action Objectives
RES	Residential Exposure
RfD	Reference Dose
ROD	Record of Decision
RWQCB	California Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act of 1986
SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
SVE	Soil Vapor Extraction
SWRCB	State Water Resource Control Board
SWRI	Site Wide Remedial Investigation
TCE	Trichloroethylene
TFC	Total Field Cost
Tmss	Miocene Cierbo Formation
Tnbs 1	Miocene Neroly Formation - Lower Blue Sandstone Member

Tnbs 2	Miocene Neroly Formation - Upper Blue Sandstone Member
Tnsc 1	Miocene Neroly Formation - Middle Siltstone/Claystone Member
UCRL	University of California Radiation Laboratory
UCL	Upper Confidence Limit
VOCs	Volatile Organic Compounds